DECLARATION

I, Masaaki Hagiwara, of c/o SHIGA INTERNATIONAL PATENT OFFICE, 2-3-1 Yaesu, Chuo-ku, Tokyo 104-8453 JAPAN, understand both English and Japanese, am the translator of the English document attached, and do hereby declare and state that the attached English document contains an accurate translation of the official certified copy of Japanese Patent Application No. 2003-145228 and that all statements made herein are true to the best of my knowledge.

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[Title of the Invention] Variable topology network system, central control unit and wavelength tunable light source unit thereof, and computer programs thereof
[Claims]

[Claim 1] A variable topology network system comprising:

two or more communication nodes each consisting of a wavelength tunable light source unit having three different input/output ports, a communication node device optical input/output port, a WDM optical input/output port for transmitting/receiving and converting optical signal wavelengths from communication node devices, and a control signal input/output port, and a communication node device having an optical input/output port connected to said communication node device optical input/output port of said wavelength tunable light source unit via an optical waveguide;

an arrayed waveguide diffraction grating (AWG) wavelength routing unit;

optical waveguides connecting said WDM optical input/output ports of said wavelength tunable light source units to the corresponding optical input/output ports of said arrayed waveguide diffraction grating (AWG) wavelength routing unit; and

one or more central control units connected to said control signal input/output ports of said wavelength tunable light source units via optical waveguides, wherein:

said central control unit controls the oscillation wavelengths of one or more wavelength tunable light sources mounted in said wavelength tunable light source units, whereby a distributed iDC (Internet data center) network or a distributed IX (Internet exchange) network in which said communication node devices can constitute at least one of the following networks is established: logical star topology, logical ring topology, and logical mesh topology networks and a network of their mixture, wherein:

said wavelength tunable light source unit comprises:

a node database provided at least either inside or outside the unit;

a means for storing a list of usable wavelengths in said node database and recording a wavelength currently in use in said node database;

a means for changing operation wavelength data registered in said node database when some operating wavelengths between said wavelength tunable light source units are changed; and

a means for monitoring the connection state between said wavelength tunable light source unit and said communication node device; and

said central control unit comprises:

a central data base provided at least either inside or outside the unit;

a means for recording all wavelengths used by said wavelength tunable light source units and monitoring and recording in said central database the optical transmission and

reception intensities of the wavelengths used by all of said wavelength tunable light source units;

a means for monitoring and recording in said central database the connection states between said wavelength tunable light source units;

a means for monitoring and recording in said central database the connection states between said wavelength tunable light source units and said communication node devices;

a means for changing operating wavelengths stored in said central database when some operating wavelengths between said wavelength tunable light source units are changed;

a means for controlling the disconnection of wavelength signals between said wavelength tunable light source units; and

a means for controlling the change of the wavelengths used to connect said wavelength tunable light source units.

[Claim 2] The variable topology network system according to Claim 1 wherein said wavelength tunable light source unit comprises:

N (N is an integer equal to 2 or greater) wavelength tunable light sources that convert input electric signals into optical signals and output them while determining the wavelength of said optical signals based on wavelength control signals;

N optical receivers that convert input signal light into electric signals and output them;

N electric-optical converters that have outputs connected to said communication node device optical input/output port, convert input electric signals into optical signals, and output them;

N optical-electric converters that have inputs connected to said communication node device optical input/output port, convert input optical signals into electric signals, and output them;

an optical coupler that receives signal lights from said N wavelength tunable light sources via optical waveguides and multiplexes and outputs the input signal lights to said WDM connection optical input/output port to generate WDM signals to said AWG;

a 1 x N – DEMUX filter that receives and demultiplexes WDM signals arriving at said WDM connection optical input/output port from said AWG and outputs the demultiplexed signal lights to said N different optical receivers;

an N x N switch that receives electric signals from said N optical receivers and outputs the input electric signals from any of N output ports based on a first switch control signal.

a 2N x 2N switch that is connected at the input to the outputs of said N optical-electric converters and said N x N switch and at the output to the inputs of said N electric-optical converters and said wavelength tunable light sources, outputs electric signals from said N x N switch either to said electric-optical converters or to said wavelength tunable light sources based on a second switch control signal, and outputs electric signals from said optical-electric converters to said wavelength tunable light sources;

a wavelength tunable light source control means that outputs said wavelength control signals for individually controlling the oscillation wavelengths of said wavelength tunable light sources;

a monitoring means that monitors the intensities of optical outputs from said wavelength tunable light sources and the intensities of optical signals to said optical receivers;

a switch control means that outputs said first switch control signal and said second switch control signal;

an administration means connected to said node database;

a display control means that displays information monitored by said monitoring means and information administrated by said administration means; and

a control signal transmission/reception means connected to said control signal input/output port.

[Claim 3] The variable topology network system according to Claim 1 wherein said central control unit comprises:

a control signal input/output port that serves as a control signal interface to all of said wavelength tunable light source units;

a control signal transmission/reception means that transmits/receives control signals to/from said wavelength tunable light source units via said control signal input/output port;

a monitoring means that monitors the states of all of said wavelength tunable light source units based on said control signals;

a charge calculation means that calculates charge for each one of the wavelength paths of communication nodes used in the network; and

a display control means that serves as an interface to a topology administrator terminal.

[Claim 4] The variable topology network system according to Claim 1 or 2 comprising a means for reading information including usable wavelength bands, all wavelengths currently in use, optical transmission and reception intensities of each wavelength signal, connection state between said wavelength tunable light sources units, and logical topologies currently connected in said node database of each wavelength tunable light source unit upon request from said central control unit and informing said central control unit of these.

[Claim 5] The variable topology network system according to Claim 1 or 3 wherein:

said central control unit has a means for detecting and informing said wavelength tunable light source units of abnormal conditions in the connection states among all of said

wavelength tunable light source units and the optical transmission and reception intensities of wavelength signals of said wavelength tunable light source units; and

said wavelength tunable light source units have a means for constantly monitoring the optical transmission and reception intensities of wavelength signals and detecting and informing said central control unit of abnormal conditions in these.

[Claim 6] The variable topology network system according to Claim 1 comprising a means for said central control unit giving a failed wavelength tunable light source unit an order to shut down the wavelength tunable light sources and giving the two immediately adjacent wavelength tunable light source units connected to the failed wavelength tunable light source unit an order to bypass the failed communication node when a logical ring topology network connecting said communication node devices is established and a failure occurs in the communication node device connected to a specific wavelength tunable light source unit, a specific wavelength tunable light source unit, or the optical waveguide connecting a specific wavelength tunable light source unit and said arrayed waveguide diffraction grating (AWG) wavelength routing unit, whereby a logical ring topology in which the failed communication node is bypassed is reestablished.

[Claim 7] The variable topology network system according to Claim 1 comprising a means for said central control unit giving a failed wavelength tunable light source unit an order to transmit two bidirectional wavelength signals constituting a double ring topology through one optical fiber of the failed twin-core optical fiber among the twin-core optical fibers connecting the arrayed waveguide diffraction grating (AWG) wavelength routing unit and the wavelength tunable light source units or through one of the two failed waveguides when a logical ring topology network connecting said communication node devices is established and a failure occurs in the communication node device connected to a specific wavelength tunable light source unit, a specific wavelength tunable light source unit, or the optical waveguide connecting a specific wavelength tunable light source unit and said arrayed waveguide diffraction grating (AWG) wavelength routing unit, whereby said logical ring topology network is maintained.

[Claim 8] The variable topology network system according to any of Claims 1 to 5 wherein said wavelength tunable light source unit is constituted as a physical gateway for transmitting/receiving control signals to/from said central control unit and as an administrative gateway for informing the administrative body of said communication node of the states of operating wavelengths used by said administrative body of the wavelength tunable light source unit, logical topologies currently connected, logical topology change schedule, failure reports, and failure history request.

[Claim 9] The variable topology network system according to any of Claims 1 to 5 wherein said wavelength tunable light source unit is constituted as a physical gateway for transmitting/receiving control signals to/from said central control unit, and

said central control unit comprises:

a means for determining the availability through calculation with reference to said central database when a communication node makes to said central control unit a request to change connection from the currently connected logical topology to a different logical topology; and,

in case that the availability is confirmed,

a means for informing all wavelength tunable light source units within the logical topology to which the communication node that has made the logical topology connection change request is connected of the removal of the communication node and wavelength resetting and updating information stored in said central database and node database; and

a means for informing all wavelength tunable light source units within the logical topology to which the communication node that has made the logical topology connection change request will be connected of the entry of the communication node and wavelength resetting and updating information stored in said central database and node database.

[Claim 10] The variable topology network system according to any of Claims 1 to 5 wherein said wavelength tunable light source unit is constituted as a physical gateway for transmitting/receiving control signals to/from said central control unit, and

said central control unit comprises:

a means for calculating additional charge necessary for a new wavelength path with reference to said central database and recording the calculation result in said central database when a specific communication node makes a topology change request and a new wavelength path is established in the course of the topology change; and

a means for informing said communication node of information on said additional charge.

[Claim 11] The variable topology network system according to any of Claims 1 to 5 wherein said wavelength tunable light source unit is constituted as a physical gateway for transmitting/receiving control signals to/from said central control unit, and

said central control unit comprises:

a means for calculating reduction in charge for a removed wavelength path with reference to said central database and recording the calculation result in said central database when a specific communication node makes a topology change request and a wavelength path is removed in the course of the topology change; and

a means for informing said communication node of said reduction in charge.

[Claim 12] The variable topology network system according to any of Claims 1 to 5 wherein said wavelength tunable light source unit is constituted as a physical gateway for transmitting/receiving control signals to/from said central control unit, and

said central control unit comprises:

either one of the following means: a means for determining whether or not band speed-up between specific communication nodes is available through calculation with reference to said central database and, if the band speed-up is available by establishing a wavelength bypass through some other communication nodes that are not directly connected to said communication nodes, establishing a new wavelength path between said specific communication nodes and said bypass communication nodes by informing the wavelength tunable light source units of these communication nodes of wavelength resetting for the new wavelength path, and updating information stored in said central database when an increased traffic flow between specific communication nodes imposes a load on the network and said specific communication nodes make a request for band speed-up between them to said central control unit, and

a means for determining whether or not band speed-up between specific communication nodes is available through calculation with reference to said central database and, if the band speed-up is available by using an idle wavelength of a communication node connected to another logical topology to which said communication nodes are not connected, establishing a new wavelength path between the bypass communication node and said specific communication nodes by informing the wavelength tunable light source units of these communication nodes of wavelength resetting for the new wavelength path, and updating information stored in said central database when an increased traffic flow between specific communication nodes imposes a load on the network and said specific communication nodes make a request of band speed-up between them to said central control unit,

said central control unit comprises:

a means for calculating additional charge necessary for a new wavelength path with reference to said central database, recording it in said central database, and informing said communication nodes of the charge; and

a means for calculating reduction in charge for the communication nodes that offer the wavelength path, recording it in said central database, and informing said communication nodes of the reduction in charge.

[Claim 13] A wavelength tunable light source unit having three different input/output ports, a communication node device optical input/output port, a WDM optical input/output port for transmitting/receiving and converting optical signal wavelengths from communication node devices, and a control signal input/output port, and used in a variable topology network system, comprising:

N (N is an integer equal to 2 or greater) wavelength tunable light sources that convert input electric signals into optical signals and output them while determining the wavelength of said optical signals based on wavelength control signals;

N optical receivers that convert input signal light into electric signals and output them;

N electric-optical converters that have outputs connected to said communication node device optical input/output port, convert input electric signals into optical signals, and output them;

N optical-electric converters that have inputs connected to said communication node device optical input/output port, convert input optical signals into electric signals, and output them;

an optical coupler that receives signal lights from said N wavelength tunable light sources via optical waveguides and multiplexes and outputs the input signal lights to said WDM connection optical input/output port to generate WDM signals to said AWG;

a 1 x N – DEMUX filter that receives and demultiplexes WDM signals arriving at said WDM connection optical input/output port from said AWG and outputs the demultiplexed signal lights to said N different optical receivers;

an N x N switch that receives electric signals from said N optical receivers and outputs the input electric signals from any of N output ports based on a first switch control signal.

a 2N x 2N switch that is connected at the input to the outputs of said N optical-electric converters and said N x N switch and at the output to the inputs of said N electric-optical converters and said wavelength tunable light sources, outputs electric signals from said N x N switch either to said electric-optical converters or to said wavelength tunable light sources based on a second control signals, and outputs electric signals from said optical-electric converters to said wavelength tunable light sources;

a wavelength tunable light source control means that outputs said wavelength control signals for individually controlling the oscillation wavelengths of said wavelength tunable light sources;

a monitoring means that monitors the intensities of optical outputs from said wavelength tunable light sources and the intensities of optical signals to said optical receivers;

a switch control means that outputs said first switch control signal and said second switch control signal;

an administration means having a node database, storing a list of usable wavelengths in said node database and recording wavelengths currently in use in said node database, and changing operating wavelength data in said node database when the wavelengths used between some wavelength tunable light source units are changed based on information monitored by said monitoring means;

a display control means that displays information monitored by said monitoring means and information administrated by said administration means; and

a control signal transmission/reception means connected to said control signal input/output port.

[Claim 14] A central control unit connected to wavelength tunable light source units via waveguides for controlling and administrating the operations of said wavelength tunable light source units in a variable topology network system comprising two or more wavelength tunable light source units and an arrayed waveguide diffraction grating (AWG) wavelength routing unit mutually connecting said wavelength tunable light source units, comprising:

a central database provided at least either inside or outside the unit;

a means for recording all wavelengths used by said wavelength tunable light source units and monitoring and recording in said central database the optical transmission and reception intensities of the wavelengths used in all of said wavelength tunable light source units;

a means for monitoring and recording in said central database the connection states between said wavelength tunable light source units;

a means for monitoring and recording in said central database the connection states between said wavelength tunable light source units and said communication nodes;

a means for changing operating wavelengths stored in said central database when operating wavelengths between said wavelength tunable light source units are changed;

a means for controlling the disconnection of wavelength signals between said wavelength tunable light source units, and

a means for controlling the change of wavelength used to connect said wavelength tunable light source units.

[Claim 15] The central control unit according to Claim 14 comprising:

a control signal input/output port serving as a control signal interface to all the wavelength tunable light source units;

a control signal transmission/reception means that transmits/receives control signals to/from said wavelength tunable light source units via said control signal input/output port;

a monitoring means that monitors the states of all of said wavelength tunable light source units based on said control signals;

a charge calculation means that calculates charge for each one of the wavelength paths of communication nodes used in the network based on the monitoring result; and

a display control means serving as an interface to a topology administrator terminal.

[Claim 16] A computer program for operating a wavelength tunable light source unit constituted by a computer unit having three different input/output ports, a communication node device optical input/output port, a WDM optical input/output port

for transmitting/receiving and converting optical signal wavelengths from communication node devices, and a control signal input/output port and used in a variable topology network system, said wavelength tunable light source unit comprising N (N is an integer equal to 2 or greater) wavelength tunable light sources that convert input electric signals into optical signals and output them while determining the wavelength of said optical signals based on wavelength control signals; N optical receivers that convert input signal light into electric signals and output them; N electric-optical converters that have outputs connected to said communication node device optical input/output port, convert input electric signals into optical signals, and output them; N optical-electric converters that have inputs connected to said communication node device optical input/output port, convert input optical signals into electric signals, and output them; an optical coupler that receives signal lights from said N wavelength tunable light sources via optical waveguides, multiplexes and outputs the input signal lights from said WDM connection optical input/output port to generate WDM signals to said AWG; a 1 x N – DEMUX filter that receives and demultiplexes WDM signals arriving at said WDM connection optical input/output port from said AWG and outputs the demultiplexed signal lights to said N different optical receivers; an N x N switch that receives electric signals from said N optical receivers and outputs the input electric signals from any of N output ports based on a first switch control signal; and a 2N x 2N switch that is connected at the input to the outputs of said N optical-electric converters and said N x N switch and at the output to the inputs of said N electric-optical converters and said wavelength tunable light sources, outputs electric signals from said N x N switch either to said electric-optical converter or to said wavelength tunable light sources based on a second witch control signal, and outputs electric signals from said optical-electric converters to said wavelength tunable light sources; characterized by including the following steps:

supplying said wavelength control signals for individually controlling the oscillation wavelengths of said wavelength tunable light sources;

monitoring the intensities of optical outputs from said wavelength tunable light sources and the intensities of optical signals to said optical receivers;

supplying said first switch control signal and said second switch control signal;

storing a list of usable wavelengths in said node database and recording wavelengths currently in use in said node database, and changing operating wavelength data stored in said node database when operating wavelengths between some wavelength tunable light source units are changed based on information monitored by said monitoring means; and

displaying information monitored by said monitoring means and information administrated by said administration means.

[Claim 17] A computer program for operating a central control unit constituted by a computer unit connected to wavelength tunable light source units via optical waveguides

for controlling and administrating the operations of said wavelength tunable light source units in a variable topology network system comprising two or more wavelength variable light source units and an arrayed waveguide diffraction grating (AWG) wavelength routing unit mutually connecting said wavelength tunable light source units, characterized by including the following steps:

recording all wavelengths used by said wavelength tunable light source units and monitoring and recording in said central database the optical transmission and reception intensities of the wavelengths used by all of said wavelength tunable light source units;

monitoring and recording in said central database the connection states between said wavelength tunable light source units;

monitoring and recording in said central database the connection states between said wavelength tunable light source units and said communication nodes;

changing operating wavelengths registered in said central database when operating wavelengths between said wavelength tunable light source units are changed;

controlling the disconnection of wavelength signals between said wavelength tunable light source units; and

controlling the change of wavelength used to connect said wavelength tunable light source units.

[Claim 18] The computer program for a central control unit according to Claim 17 characterized by including the following steps:

transmitting/receiving control signals to/from said wavelength tunable light source units;

monitoring the states of all wavelength tunable light source units based on said control signals; and

calculating charges for each one of the wavelength paths of communication nodes used in the network based on monitoring results.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to a variable topology network system easily applicable to a local distributed iDC (Internet data center) or IX (Internet exchange) network and in which logical topologies can easily be changed, wavelength tunable light source unit and central control unit thereof, and computer programs thereof.

[0002]

[Prior Art]

Currently, as an increasing number of local public networks are established, there is a growing demand for dynamic changes in network topologies in association with mutual

connection between municipal networks having different network topologies, addition or removal of communication nodes, and unification or expansion of organizations and dynamic changes in wavelength paths for failure bypassing. To this end, a variable arbitrary logical topology network realized by an arrayed waveguide diffraction grating (AWG) wavelength routing function and wavelength tunable light sources mounted in communication nodes connected to the arrayed waveguide diffraction grating (AWG) wavelength routing function physically in a star shape appears promising and has been under development.

[0003]

[Non-patent document 1]

K. Kato et al., "32 x 32 full-mesh (1024 path) wavelength-routing WDM network based on uniform-loss cyclic-frequency arrayed-waveguide grating," Electronics Letters, vol. 33, 1865-1866, 1977.

[Non-patent document 2]

Chikashi Shimura, "Proposal of Municipal Body Shared IDC Business to Promote Electronic Municipal Bodies," Nomura Research Institute Local Business Newsletter, vol. 34, June 2001.

[0004]

[Problems to be Solved by the Invention]

However, techniques for setting, monitoring, and administrating wavelength paths have to be developed for smooth operation of a variable arbitrary logical topology network system. Changes in logical topologies, addition or removal of communication nodes, and changes or addition of wavelength paths for failure bypassing are cumbersome tasks and these lead to changes in charge to users for the use of wavelength paths. This also requires a cumbersome task.

[0005]

In view of the above problems, the purpose of the present invention is to provide a variable topology network system that facilitates the installation and usage of a variable logical topology network system applicable to a local distributed iDC (Internet data center) or IX (Internet exchange) network and realized by an arrayed waveguide diffraction grating (AWG) wavelength routing function and wavelength tunable light sources mounted in communication nodes connected to the arrayed waveguide diffraction grating (AWG) wavelength routing function physically in a star shape via optical waveguides such as optical fibers, central control system and wavelength tunable light source unit thereof, and computer programs thereof.

[0006]

[Means for Solving the Problem]

In order to achieve the above purpose, the present invention proposes a variable topology network system comprising two or more communication nodes each consisting of

a wavelength tunable light source unit having three different input/output ports, a communication node device optical input/output port, a WDM optical input/output port for transmitting/receiving and converting optical signal wavelengths from communication node devices, and a control signal input/output port, and a communication node device having an optical input/output port connected to the communication node device optical input/output port of the wavelength tunable light source unit via an optical waveguide; an arrayed waveguide diffraction grating (AWG) wavelength routing unit; optical waveguides connecting the WDM optical input/output ports of the wavelength tunable light source units to the corresponding optical input/output ports of the arrayed waveguide diffraction grating (AWG) wavelength routing unit; and one or more central control units connected to the control signal input/output ports of the wavelength tunable light source units via optical waveguides, wherein the central control unit controls the oscillation wavelengths of one or more wavelength tunable light sources mounted in the wavelength tunable light source units, whereby a distributed iDC (Internet data center) network or a distributed IX (Internet exchange) network in which the communication node devices can constitute at least one of the following networks is established: logical star topology, logical ring topology, and logical mesh topology networks and a network of their mixture, wherein the wavelength tunable light source unit comprises a node database provided at least either inside or outside the unit; a means for storing a list of usable wavelengths in the node database and recording a wavelength currently in use in the node database; a means for changing operating wavelength data registered in the node database when some operating wavelengths between the wavelength tunable light source units are changed; and a means for monitoring the connection state between the wavelength tunable light source unit and the communication node device; and the central control unit comprises a central data base provided at least either inside or outside the unit; a means for recording all wavelengths used by the wavelength tunable light source units and monitoring and recording in the central database the optical transmission and reception intensities of the wavelengths used by all of the wavelength tunable light source units; a means for monitoring and recording in the central database the connection states between the wavelength tunable light source units; a means for monitoring and recording in the central database the connection states between the wavelength tunable light source units and the communication node devices; a means for changing the operating wavelengths registered in the central database when some operating wavelengths between the wavelength tunable light source units is changed; a means for controlling the disconnection of wavelength signals between the wavelength tunable light source units; and a means for controlling the change of wavelength used to connect the wavelength tunable light source units.

[0007]

According to the present invention, all communication nodes constituting a distributed

iDC (Internet Data Center) network system or a distributed IX (Internet Exchange) network system are provided with a communication node device and a wavelength tunable light source unit, which are connected to each other via an optical waveguide such as an optical fiber. The wavelength tunable light source unit is connected to an arrayed waveguide diffraction grating (AWG) wavelength routing unit via an optical waveguide such as an optical fiber. Following this process, all communication node devices and wavelength tunable light source units and the arrayed waveguide diffraction grating (AWG) wavelength routing unit are connected, whereby a physical star topology is established around the arrayed waveguide diffraction grating (AWG) wavelength routing unit.

[0008]

Optical signals from a communication node device are converted into a specific wavelength corresponding to communication path information by the wavelength tunable light source unit and, then, directed to the arrayed waveguide diffraction grating (AWG) wavelength routing unit connected to the wavelength tunable light source unit via an optical waveguides such as an optical fiber. Then, the signals reach a counter-posed wavelength tunable light source unit and further the communication node device connected thereto.

[0009]

In some networks, a specific group of communication nodes among all communication nodes are full-mesh connected, another group of communication nodes are star-connected, yet another groups of communication nodes are ring-connected, and yet another group of communication nodes are partial-mesh connected. By controlling wavelength paths necessary for some communication nodes to constitute a specific network topology using the wavelength tunable light source unit, multiple logical network topologies can be constituted on a single star topology physically realized through connections by waveguides such as optical fibers. Here, the number of operating wavelengths used by the wavelength tunable light source units connected to the reconstituted logical topology and the related charge are calculated and recorded by the central control unit.

[0010]

When band speed-up is desired between specific communication nodes because of an increased traffic volume, a bypass can be established by passing through some wavelength tunable light source units connected to the same logical topology. In such a case, the increase/decrease in number of operating wavelengths used by the wavelength tunable light source units connected to the reconstituted logical topology and the increase/decrease in related charge are calculated and recorded by the central control unit.

[0011]

Furthermore, when band speed-up is desired between specific communication nodes because of an increased traffic volume, a bypass can be established by passing through

some wavelength tunable light source units connected to a different logical topology. In such a case, the increase/decrease in number of wavelengths loaned from the different logical topology and increase/decrease in related charge and the increase/decrease in number of operating wavelengths used by the wavelength tunable light source units connected to the logical topology reconstituted using the loaned wavelength path and increase/decrease in related charge are calculated and recorded by the central control unit.

[0012]

[Embodiments of the Invention]

Embodiments of the present invention are described hereafter with reference to the drawings.

[0013]

This embodiment explains a variable arbitrary logical topology network system applicable to a local distributed iDC (Internet data center) or IX (Internet Exchange) network and realized by an arrayed waveguide diffraction grating (AWG) wavelength routing function and wavelength tunable light sources mounted in communication nodes connected to the arrayed waveguide diffraction grating (AWG) wavelength routing function physically in a star shape via optical waveguides such as optical fibers, the network system providing communication service for which the wavelength usage charge is increased or decreased according to addition of a new wavelength path or removal of an operating wavelength path in the course of a logical topology change and communication service in which band speed-up between specific communication nodes is realized by using an idle wavelength path from a communication node connected to another logical topology, additional charge for the use of a new wavelength path in association with band speed-up is imposed, and, when the communication node that has offered the idle wavelength path belongs to a different administration body, reduction in wavelength path usage charge for the offered wavelength path is applied.

[0014]

[Embodiment 1]

Fig.1 is an illustration showing the entire configuration of a variable topology network system according to an embodiment of the present invention. In the figure, four communication node devices (1001-1004) and four optical input/output ports (1301-1304) of an arrayed waveguide diffraction grating (AWG) are provided. However, two or more each of them can be provided. Furthermore, one arrayed waveguide diffraction grating (AWG) (101) and one central control unit (2001) is provided in the figure. Multiple numbers can be provided for redundant configuration.

[0015]

The optical input/output ports (901-904) of the communication node devices (1001-1004) are connected to the communication node device optical input/output ports (601-604) of wavelength tunable light source units (301-304) via optical waveguides (1801-1804) such

as optical fibers. The wavelength of signal light from the communication node devices is converted to a WDM signal wavelength by the wavelength tunable light source units (301-304). The WDM signal light is output from the WDM optical input/output ports (401-404) of the wavelength tunable light source units (301-304), guided to optical waveguides (1101-1104) such as optical fibers, or transfer paths, via WDM filters (1201-1204) connected by optical waveguides (1401-1404) such as optical fibers, and reaches the subsequent WDM filters (1301-1304). Then, the light is guided by optical waveguides (1601-1604) such as optical fibers to the optical input/output ports (201-204) of the arrayed waveguide diffraction grating (AWG).

[0016]

The arrayed waveguide diffraction grating (AWG) (101) conducts optical layer routing to different optical ports depending on the wavelength of input optical signals. In this way, signal light output from the communication node devices (1001-1104) and of which the wavelength is converted by the wavelength tunable light source units (301-304) is directed any of the counter-posed communication node devices (1001-1104) by the arrayed waveguide diffraction grating (AWG) (101).

[0017]

For the wavelength conversion of the wavelength tunable light source units (301-304), the central control unit (2001) has a total control over multiple wavelength tunable light source units (301-304). For this control, the wavelength tunable light source units (301-304) and central control unit (2001) communicates with each other using, in the case of Fig. 1, the same optical waveguides (1104-1104) such as optical fibers as used for transferring WDM signal light from the wavelength tunable light source units (301-304).

[0018]

It is unnecessary to use the same waveguides. Other optical waveguides such as an optical fibers cab be provided and connected to a consolidator (1901).

[0019]

Control signals from the control signal input/output ports (501-504) of the wavelength tunable light source units (301-304) reach the WDM filters (1201-1204) via optical waveguides (1501-1504) such as optical fibers and further reach the counter-posed WDM filters (1301-1304) via the facing optical waveguides (1101-1104). Then, they reach the consolidator (1901) via optical waveguides (1701-1704) such as optical fibers. Consequently, control signals from all wavelength tunable light source units (301-304) reach the consolidator (1901) and arrive at the optical input/output port (2201) of the central control unit (2001) where the control signals are subject to operations. Conversely, control signals from the central control system (2001) travel as follows: the optical input/output port (2201) of the central control unit → the consolidator (1901) → the WDM filters (1301-1304) → the WDM filters (1201-1204) → the control signal input/output ports (501-504) of the wavelength tunable light source units (301-304).

[0020]

To each wavelength tunable light source unit (301-304) connected are a wavelength tunable light source unit internal database (701-704) and a wavelength tunable light source unit external database (801-804) (node databases). To the central control unit (2001) connected are a central control unit internal database (2301) and a central control unit external database (2401) (central database).

[0021]

When a logical ring topology network connecting the communication node devices (1001-114) is established and any of the following failures occurs: a failure in the communication node device (1001-1004) connected to a specific wavelength tunable light source unit (301-304), a failure in a specific wavelength tunable light source unit (301-304), and a disconnection failure in an optical waveguide connecting a specific wavelength tunable light source unit (301-304) and the arrayed waveguide diffraction grating (AWG) wavelength routing unit (101), the central control unit (2001) gives the wavelength tunable light source unit (301-304) where the failure has occurred an order to transmit/receive two bidirectional wavelength signals constituting a double ring topology through one optical fiber of the failed twin-core optical fiber among the twin-core optical fibers connecting the arrayed waveguide diffraction grating (AWG) wavelength routing unit (101) and the wavelength tunable light source unit (301-304) or through one of the two failed optical waveguides, thereby maintaining the logical ring topology.

[0022]

[Embodiment 2]

Fig.2 is an illustration showing the internal configuration of the wavelength tunable light source units (301-304).

[0023]

Optical signals from the communication node device optical input/output port (601-604) are converted into electric signals by optical-electric converters (3004-3006) before they reach a 2N x 2N electric switch (2702). Then, they are converted into WDM signal wavelengths by the wavelength tunable light sources (2501-2503), multiplexed by an optical coupler (2801), reach the WDM connection optical input/output port (401-404), and exit outside.

[0024]

Conversely, WDM signal light arriving at the WDM connection optical input/output port from outside reaches a DEMUX filter (2901) and de-multiplexed into different wavelengths. The wavelengths each reach optical receivers (2601-2603), where optical signals are converted into electric signals and reach an N x N switch (2701). Passing through the N x N switch (2701), the signals reach the subsequent 2N x 2N electric switch (2702) for directing them either to the communication node device optical input/output port (601-604) or to the wavelength tunable light sources (2501-2503).

[0025]

When optical signals having a specific wavelength among WDM signals arriving from outside are directed to the wavelength tunable light sources (2501-2503), not to the communication node device (1001-1004), and the communication node devices (1001-1004) is skipped, the 2N x 2N electric switch (2702) switches the signal path to a specific wavelength tunable light source (2501-2503).

[0026]

In order for signals from outside to reach the communication node device (1001-1004), signals passing through the 2N x 2N electric switch (2702) are directed to electric-optical converters (3001-3003), where signals are converted into optical signals. Then, they pass through the communication node device input/output port (601-604) and reach the communication node device (1001-1004).

[0027]

In the wavelength tunable light source unit (301-304), a control part (3107) is connected to a wavelength tunable light source control part (3101), a monitoring part (3102), a switch control part (3103), a control signal transmission part (3104), an administration part (3105), and a display control part (3106), providing total control using a combination of hardware and software including microcomputers.

[0028]

The wavelength tunable light source control part (3101) is connected to the wavelength tunable light sources (2501-2503) to control wavelength conversion. The monitoring part (3102) is connected to the wavelength tunable light sources (2501-2503) to monitor the optical output intensity and connected to the optical receivers (2601-2603) to monitor the optical input intensity.

[0029]

The switch control part (3103) is connected to the two switches (2701, 2702) to control the switches. The control signal transmission part (3104) is connected to the control signal input/output port (501-504) to generate control signals. The administration part (3105) serves as an input/output interface to the internal database (701-704) and external database (801-804) connected thereto. The display control part (3106) serves as an interface to the communication node administrator terminal (3201) to generate and control display signals for providing information to the communication node administrator (3202).

[0030]

[Embodiment 3]

Fig.3 is an illustration showing the internal configuration of the central control unit (2001).

[0031]

A control part (3306) is connected to a control signal transmission/reception part (3301), a monitoring part (3303), an administration part (3303), a display control part (3304), and

a charge calculation part (3305) to control them using a combination of hardware and software including microcomputers.

[0032]

The control signal transmission/reception part (3301) is connected a control signal input/output port (2201) to serve as an interface to the control signal input/output port (2201) for delivering control signals received at the control signal input/output port (2201) to the control part (3306) and for generating signals from control information produced by the control part (3306) and delivering them to the control signal input/output port (2201).

[0033]

The monitoring part (3302) constantly watches for monitoring information among information sent from all wavelength tunable light source units (301-304) to monitor the states of the wavelength tunable light source units (301-304). When the wavelength tunable light source units (301-304) are in a normal state, the monitoring part (3302) supplies the administration part (3303) with normal state information through the control part (3306) to record it in the internal database (2301) and external database (2401) connected to the administration part (3303). When an abnormal state is found while constantly watching for monitoring information among information sent from all wavelength tunable light source units (301-304), the monitoring part (3302) supplies the administration part (3303) with abnormal state information through the control part (3306) to record it in the internal database (2301) and external database (2401) connected to the administration part (3303). Furthermore, it informs all wavelength tunable light source units (301-304) of the occurrence of an abnormal state through the control signal transmission/reception part (3301) → the control signal input/output port (2201).

[0034]

The display control part (3304) serves as an interface to the topology administrator terminal (3401) for generating information given to the topology administrator (3402) and sending all operations performed by the topology administrator (3402) to the control part (3306). The charge calculation part (3305) reads the current topology structure and information in the internal database (2301) and external database (2401) connected to the administration part (2301) and storing topology user information through the control part (3306), calculates the charge, and give the latest charge to the administration part (3303) again through the control part to record it in the internal database (2301) and external database (2401) connected to the administration part (2301).

[0035]

[Embodiment 4]

Fig.4 shows information (3501) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) and "administrative communication node number," "grid interval," and "usable wavelength" information stored in internal database (2301) and external database (2401) connected to

the central control unit (2001).

[0036]

The wavelength tunable light source units (301-304) each have a unique administrative communication node number, grid interval, and usable wavelength information. When the wavelength tunable light sources are activated, control signals are sent from the control signal input/output port (501-504) to the central control unit (2001) and integrated in the internal database (2301) and external database (2401) connected to the central control unit (2001), whereby the above information is stored in the format (3502) shown in Fig.5.

[0037]

[Embodiment 5]

Figs. 6, 7, and 8 are illustrations for explaining administrative information at the central control unit (2001) for two users of different topologies.

[0038]

Fig.6 shows central control topology administrative information (3601) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001).

[0039]

The following information is integrated: "the topology type" currently in use; "administrative communication node number" corresponding to the wavelength tunable light source unit central control individual number necessary for the central control unit to access all of the wavelength tunable light source units (301-304); "user communication node number" corresponding to the wavelength tunable light source unit user control individual number necessary for the user to access the wavelength tunable light source units (301-304) constituting the topology he/she uses; "user ID" that is the topology user individual number; "operating wavelength" used by the wavelength tunable light source units; "counter-posed communication node number" that is the wavelength tunable light source central control individual number of the wavelength tunable light source units (301-304) connected to a specific wavelength tunable light source unit (301-304); "WDM transmission state" that is the optical output intensity of the wavelength tunable light sources within a wavelength tunable light source unit; "WDM reception state" that is the intensity of light received by the optical receivers within a wavelength tunable light source unit; "communication node connection state" that is the connection state between the wavelength tunable light source unit (301-304) and a communication node; "number of node links" is the number of wavelength tunable light source unit (301-304) connected to a wavelength tunable light source units (301-304); "link band speed-up" that is the indication that speed-up is applied between specific wavelength tunable light source units (301-304); and "speed-up period" that is the period the speed-up is applied.

[0040]

The central control topology administrative information (3601) is graphically displayed on the topology administrator terminal (3401) through the display control part (3304). The display consists of a topology administrative window (3602), a user ID "1" information window (3603), and a user ID "2" information window (3604). Here, the user 1 uses a mesh topology and the user 2 uses a mixture of ring and star topologies; however, the number of users and topology types are not restrictive.

[0041]

Fig.8 shows charge information calculated by the charge calculation part (3305) of the central control unit (2001). Information such as a unique "user ID," "month and year of the usage" for each user ID, "increase/decrease in number of communication nodes" for each user ID, "number of band speed-ups" for each user ID, "total number of wavelength links" for each user ID, "discount" for each user ID, and "charge" for each user ID is integrated in a data format (3605) and stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) as basic information for charge according to the number of node links used. The data is administrated by the administration part (3303) and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) of each user ID every month to show users their usage in the past and their due. In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0042]

[Embodiment 6]

Fig.9 shows user topology administrative information (3603) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1."

[0043]

Information regarding the user ID "1" is retrieved from the central control topology administrative information (3601) and sent to the user topology administrative information (3606) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) using control signals, whereby the user topology administrative information (3606) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1" is updated and stored. Then, the user topology administrative information is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304).

[0044]

The following information is integrated in the user topology administrative information (3606): "the topology type" currently in use; "user communication node number" that is the wavelength tunable light source unit user control individual number used by the user to

access the wavelength tunable light source units (301-304) constituting the topology he/she uses; "operating wavelength" used by the wavelength tunable light source unit (301-304); "counter-posed communication node number" used to identify a wavelength tunable light source unit (301-304) counter-connected to the wavelength tunable light source unit (301-304) with a specific wavelength; "WDM transmission state" that is the optical output intensity of the wavelength tunable light sources within a wavelength tunable light source unit (301-304); "WDM reception state" that is the intensity of light received by the optical receivers within a wavelength tunable light source unit(301-304); "communication node connection state" that is the connection state between the wavelength tunable light source unit (301-304) and a communication node; "number of node links" is the number of other wavelength tunable light source units (301-304) counter-connected to a wavelength tunable light source unit (301-304); "link band speed-up" that is the indication that speed-up is applied between specific wavelength tunable light source units (301-304); and "speed-up period" that is the period the speed-up is applied.

[0045]

Fig.10 is an illustration showing a user window (3607). The user window (3607) graphically displays to the user having a user ID "1" the user topology administrative information (3601), which is given to the communication node administrator terminal (3201) by the display control part (3106) within the wavelength tunable light source unit (301-304). The user window (3607) also shows a topology diagram, communication nodes, and connections.

[0046]

Fig.11 is an illustration showing usage information (3608) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." In the usage information (3608) integrated and stored are a user ID, month and year of the usage, increase/decrease in number of communication nodes, number of band speed-ups, total number of wavelength links, charge discount, and monthly charge, whereby usage and accounting information is always available for confirmation. In this embodiment, a monthly charge is applied; however, it is not restrictive and daily or yearly charge can be applied.

[0047]

[Embodiment 7]

Fig.12 is an illustration showing usage topology administrative information (3609) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2."

[0048]

Information regarding the user ID "2" is retrieved from the central control topology administrative information (3601) stored in the internal database (2301) and external

database (2401) connected to the central control unit (2001) and sent to the wavelength tunable light source unit (301-304) using control signals, whereby the user topology administrative information (3609) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2" is updated and stored. Then, the user topology administrative information (3609) is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304).

[0049]

The following information is integrated in the user topology administrative information (3609): "the topology type" currently in use; "user communication node number" that is the wavelength tunable light source unit user control individual number used by the user to access the wavelength tunable light source units (301-304) constituting the topology he/she uses; "operating wavelength" used by the wavelength tunable light source unit (301-304); "counter-posed communication node number" that is the wavelength tunable light source user control individual number of a wavelength tunable light source unit (301-304) counter-connected to the wavelength tunable light source units (301-304) with a specific wavelength; "WDM transmission state" that is the optical output intensity of the wavelength tunable light sources within a wavelength tunable light source unit (301-304); "WDM reception state" that is the intensity of light received by the optical receivers within the wavelength tunable light source unit(301-304); "communication node connection state" that is the connection state between the wavelength tunable light source unit (301-304) and a communication node; "number of node links" is the number of other wavelength tunable light source units (301-304) counter-connected to the wavelength tunable light source unit (301-304); "link band speed-up" that is the indication that speed-up is applied between specific wavelength tunable light source units (301-304); and "speed-up period" that is the period the speed-up is applied.

[0050]

Fig.13 is an illustration showing a user window (3610). The user window (3610) graphically displays to the user having a user ID "2" the user topology administrative information (3609), which is given to the communication node administrator terminal (3201) by the display control part (3106) within the wavelength tunable light source unit (301-304). The user window (3610) also shows a topology diagram, communication nodes, and connections.

[0051]

Fig.14 is an illustration showing usage information (3611) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2." In the usage information (3611) integrated and stored are a user ID, month and year of the usage, increase/decrease in number of communication nodes, number of band speed-ups, total

number of wavelength links, charge discount, and monthly charge, whereby usage and accounting information is always available for confirmation. In this embodiment, a monthly charge is applied; however, it is not restrictive and daily or yearly charge can be applied.

[0052]

[Embodiment 8]

Fig.15 shows central control topology administrative information (3701) stored in the internal database (3201) and external database (2401) connected to the central control unit (2001) when the user having a user ID "1" obtains an additional communication node. Here, a newly added communication node has an administrative communication node number "11" and a user communication node number "5." The new communication node (the administrative communication node number "11" and user communication node number "5") is connected to an existing communication node (the administrative communication node number "2" and user communication node number "2") and to another existing communication node (the administrative communication node number "4" and user communication node number "4"). Then, these two existing communication nodes each have two more connections. The number of node links in the central control topology administrative information (3701) is increased by 2 to 4. Information regarding the user ID "2" in the central control topology administrative information (3701) is unchanged because of no topology changes.

[0053]

The central control topology administrative information (3701) can be graphically displayed on the topology administrator terminal (3401) through the display control part (3304). The display consists of a topology administrative window (3602), a user ID "1" information window (3702), and a user ID "2" information window (3604).

[0054]

Fig.17 shows charge information (3703) calculated by the charge calculation part (3305) of the central control unit (2001). Information such as a unique "user ID," "month and year of the usage" for each user ID, "increase/decrease in number of communication nodes" for each user ID, "number of band speed-upss" for each user ID, "total number of wavelength links" for each user ID, "discount" for each user ID, and "charge" for each user ID is integrated in a data format (3703) and stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) as basic information for charge according to the number of node links used. The data is administrated by the administration part (3303) and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit of each user ID every month to show users their usage in the past and their due. Here, a new node is added to the user ID "1" in April and May of 2003. Therefore, the total number of wavelength links is increased by 2 to 14. Consequently, the charge is changed (3704). In

this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charges can be applied.

[0055]

[Embodiment 9]

Fig.18 shows user topology administrative information (3705) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Information regarding the user ID "1" is retrieved from the central control topology administrative information (3601) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) and sent to the user topology administrative information (3705) using control signals, whereby the user topology administrative information (3705) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1" is held and stored. Then, the user topology administrative information (3705) is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304).

[0056]

Additional information (3706) regarding the link between the user communication node numbers "5" and "2" and additional information (3707) regarding the link between the user communication node numbers "5" and "4" is reflected in the user topology administrative information (3705).

[0057]

Fig.19 is an illustration showing the user topology administrative information (3705) graphically displayed to the user having a user ID "1" after it is given to the communication node administrative terminal (3201) by the display control part (3106) within the wavelength tunable light source unit (301-304). The display includes a topology diagram, communication nodes, connections in a user window (3708), where the topology is changed because of a newly added node (the user communication node number "5").

[0058]

Fig.20 shows charge information (3709) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Information such as "month and year of the usage," "increase/decrease in number of communication nodes," "number of band speed-ups," "total number of wavelength links," "discount," and "charge" is integrated in a data format (3709). The items for the user ID "1" are retrieved from charge information according to the number of node links used, which is stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) every month, and given to the internal database (701-704) and external database (801-804) connected to the

wavelength tunable light source unit (301-304) belonging to the user ID "1" to show the user his/her usage in the past and due. Here, a new node is added to the user ID "1" in April and May of 2003. Therefore, the total number of wavelength links is increased by 2 to 14. Consequently, the charge is changed (3704). In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0059]

[Embodiment 10]

Fig.21 shows central control topology administrative information (3801) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) when the user having a user ID "2" obtains band speed-up between one communication node (the user communication node number "1" and administrative communication node number "5") and another communication node (the user communication node number "2" and administrative communication node number "6").

[0060]

In order to obtain band speed-up between two communication nodes through an additional wavelength path, a new wavelength path that passes through a node to which the two communication nodes have not logically connected should be established.

[0061]

By establishing a new wavelength path through the communication node (the user communication node number "1" and administrative communication node number "5") ↔ a communication node (the user communication node number "5" and administrative communication node number "9") ↔ the communication node (the user communication node number "2" and administrative communication node number "6"), band speed-up between the communication node (the user communication node number "1" and administrative communication node number "5") and the communication node (the user communication node number "2" and administrative communication node number "6") is achieved. The 2N x 2N electric switch within the wavelength tunable light source unit (301-304) at the communication node (the user communication node number "5" and administrative communication node number "9") serves to return signals from the optical receivers (2601-2603) to the wavelength tunable light sources (2501-2503).

[0062]

As for data regarding the user ID "2" in the central control topology administrative information (3801) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001), the number of node links is increased by 1 for the communication node (the user communication node number "1" and administrative communication node number "5") and the communication node (the user communication node number "5" and administrative communication node number "9") and by 2 for the communication node (the user communication node number "2" and administrative communication node number "6") because of the speed-up (3802). On the other hand, the

information regarding the user ID "1" in the central control topology administrative information (3801), no information change is made because of no topology changes.

[0063]

The central control topology administrative information (3801) can be graphically displayed on the topology administrator terminal (3401) through the display control part (3304). The graphical display consists of, as shown in Fig.22, a topology administrative window (3602), a user ID "1" information window (3603), and a user ID "2" information window (3803).

[0064]

Fig.23 shows charge information (3805) calculated by the charge calculation part (3305) of the central control unit (2001). Information such as a unique "user ID," "month and year of the usage" for each user ID, "increase/decrease in number of communication nodes" for each user ID, "number of band speed-ups" for each user ID, "total number of wavelength links" for each user ID, "discount" for each user ID, and "charge" for each user ID is integrated in a data format (3805) and stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) as charge information according to the number of node links used. The data is administrated by the administration part (3303) and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) of each user ID every month to show users their usage in the past and their due. Here, the total number of wavelength links of the user ID "2" is increased to 16 in May of 2003 because of band speed-up and, accordingly, the charge is changed (3806). In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0065]

[Embodiment 11]

Fig.24 shows user topology administrative information (3807) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2." Information regarding the user ID "2" is retrieved from the central control topology administrative information (3601) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) and sent to the wavelength tunable light source unit using control signals, whereby the user topology administrative information (3807) is held and stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2." Then, the user topology administrative information (3807) is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304).

[0066]

Additional information (3808) regarding the link between the user communication node

numbers "1" and "4" and additional information (3803) regarding the link between the user communication node numbers "2" and "4" is reflected in the user topology administrative information (3807).

[0067]

Fig.25 is an illustration showing the user topology administrative information (3807) graphically displayed to the user having a user ID "2" after it is given to the communication node administrative terminal (3201) by the display control part (3106) of the wavelength tunable light source unit (301-304). The display includes a topology diagram, communication nodes, connections in a user window (3809), where the topology is changed because of a newly added node (the user communication node number "5"). A new logical path (3810) between the user communication nodes "1" and "2" is shown.

[0068]

Fig.26 shows charge information (3811) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2." Information such as "month and year of the usage," "increase/decrease in number of communication nodes," "number of band speed-ups," "total number of wavelength links," "discount," and "charge" is integrated in a data format (3710). The items for the user ID "2" are retrieved from charge information according to the number of node links used, which is stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) every month, and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) belonging to the user ID "2" to show the user his/her usage in the past and due.

[0069]

Here, the total number of wavelength links of the user ID "2" is increased to 16 in May of 2003 because of band speed-up and, accordingly, the charge is charged (3812). In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0070]

[Embodiment 12]

Fig.27 shows central control topology administrative information (3901) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) when the user having a user ID "1" obtains band speed-up between one communication node (the user communication node number "1" and administrative communication node number "2") and another communication node (the user communication node number "4" and administrative communication node number "4").

[0071]

In order to obtain band speed-up between two communication nodes through a new wavelength path, a new wavelength path that passes through a node to which the two

communication nodes have not logically connected should be established. All communication nodes of the user ID "1" constitute a full mesh topology. Therefore, there is no room for a new wavelength path. Then, a wavelength tunable light source of a specific node of the user ID 2 is used to resolve this problem.

[0072]

By establishing a new wavelength path through the user ID "1" communication node (the user communication node number "2" and administrative communication node number "2") ↔ a user ID "2" communication node (the user communication node number "4" and administrative communication node number "8") ↔ the user ID "1" communication node (the user communication node number "4" and administrative communication node number "4"), band speed-up between the user ID "1"communication node (the user communication node number "2" and administrative communication node number "2") and the user ID "1"communication node (the user communication node number "4" and administrative communication node number "4") is achieved. The 2N x 2N electric switch (2702) within the wavelength tunable light source unit (301-304) at the user ID "2" communication node (the user communication node number "4" and administrative communication node number "9") serves to return signals from the optical receivers (2601-2603) to the wavelength tunable light sources (2501-2503).

[0073]

As for data regarding the user IDs "1" and "2" in the central control topology administrative information (3901) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001), the number of node links is increased by 1 for the user ID "1" communication node (the user communication node number "2" and administrative communication node number "2") and the user ID "1" communication node (the user communication node number "4" and administrative communication node number "4") and by 2 for the user ID "2" communication node (the user communication node number "4" and administrative communication node number "8") because of the speed-up.

[0074]

The central control topology administrative information (3901) can be graphically displayed on the topology administrator terminal (3401) through the display control part (3304). The graphical display consists of a topology administrative window (3602), a user ID "1" information window (3603), and a user ID "2" information window (3803). Here, a new path (3905) is displayed.

[0075]

Fig.29 shows charge information (3906) calculated by the charge calculation part (3305) of the central control unit (2001). Information such as a unique "user ID," "month and year of the usage" for each user ID, "increase/decrease in number of communication nodes" for each user ID, "number of band speed-ups" for each user ID, "total number of

wavelength links" for each user ID, "discount" for each user ID, and "charge" for each user ID is integrated in a data format (3906) and stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) as charge information according to the number of node links used. The data is administrated by the administration part (3303) and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) of each user ID every month to show users their usage in the past and their due. Here, the number of wavelength links of the user ID "1" is increased to 16 in May of 2003 because of band speed-up and, accordingly, the charge is changed (3907). On the other hand, a discount and the resultant charge is shown (3908) as a result of the use of a wavelength tunable light source of a wavelength tunable light source unit of the user ID "2," who is irrelevant to the user ID "1." In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0076]

[Embodiment 13]

Fig.31 shows user topology administrative information (3909) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Information regarding the user ID "1" is retrieved from the central control topology administrative information (3601) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) and sent to the wavelength tunable light source unit using control signals, whereby the user topology administrative information (3909) is held and stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Then, the user topology administrative information (3909) is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304). Here, additional information (3910) regarding the link between the user communication node numbers "2" and "4" is reflected in the user topology administrative information (3909).

[0077]

Fig.31 is an illustration showing the user topology administrative information (3909) graphically displayed to the user having a user ID "1" after it is given to the communication node administrative terminal (3201) by the display control part (3106) of the wavelength tunable light source unit (301-304). The display includes a topology diagram, communication nodes, connections in a user window (3911), where a new logical path (3912) between the user communication nodes "1" and "2" is shown.

[0078]

Fig.32 shows charge information (3913) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit

(301-304) used by the user having a user ID "1." Information such as "month and year of the usage," "increase/decrease in number of communication nodes," "number of band speed-ups," "total number of wavelength links," "discount," and "charge" is integrated in a data format (3913). The items for the user ID "1" are retrieved from charge information according to the number of node links used, which is stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) every month, and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) belonging to the user ID "1" to show the user his/her usage in the past and due. Here, the total number of wavelength links of the user ID "1" is increased to 16 in May of 2003 because of band speed-up and, accordingly, the charge is charged (3914).

[0079]

On the other hand, Fig.33 shows charge information (3915) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "2." Information such as "month and year of the usage," "increase/decrease in number of communication nodes," "number of band speed-ups," "total number of wavelength links," "discount," and "charge" is integrated in a data format (3913). The items for the user ID "2" are retrieved from charge information according to the number of node links used, which is stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) every month, and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) belonging to the user ID "2" to show the user his/her usage in the past and due. Here, a discount is applied to the user ID "2" for allowing the user ID "1," which is irrelevant to the user ID "2," to use a wavelength tunable light source within a wavelength tunable light source unit (3916). In this embodiment, a monthly charge is applied; however, this is not restrictive and daily or yearly charge can be applied.

[0080]

[Embodiment 14]

Fig.34 shows central control topology administrative information (4001) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) for a single ring topology involving only one user ID. The central control topology administrative information (4001) can be displayed on the topology administrator terminal (3401) through the control part (3304). The display consists of, as shown in Fig.35, a topology administrative window (3602) and a user ID "1" information window (4002).

[0081]

Fig.36 shows user topology administrative information (4003) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable

light source unit (301-304) used by the user having a user ID "1." Fig.37 shows the user topology administrative information (4003) graphically displayed to the user having a user ID "1" after it is given to the communication node administrator terminal by the display control part (3106) of the wavelength tunable light source unit (301-304). The display includes a topology diagram, communication nodes, and connections in a user window (4004).

[0082]

Fig.38 shows central control topology administrative information (4005) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) when a failure occurs in a communication node (the administrative communication node number "4" and user communication node number "4") used by the user having a user ID "1" and the failed communication node is removed. As a result of the removal, the communication node (the administrative communication node number "4" and user communication node number "4") has "0" node link and the wavelength tunable light source within the wavelength tunable light sources unit (301-304) are turned "off" (4006). Furthermore, the failed communication node is skipped and wavelengths are reset for the adjacent communication nodes in the ring topology. Consequently, the wavelength tunable light source unit constituting the failed communication node receives no WDM signals and, therefore, the WDM reception is marked as "NG" (4006).

[0083]

Fig.39 shows the central control topology administrative information (4001) graphically displayed on the topology administrator terminal (3401) through the display control part (3304). The display consists of a topology administrative window (3602) and a user ID "1" information window (4407).

[0084]

Fig.40 shows charge information (4009) calculated by the charge calculation part (3305) of the central control unit (2001). Information such as a unique "user ID," "month and year of the usage" for each user ID, "increase/decrease in number of communication nodes" for each user ID, "number of band speed-ups" for each user ID, "total number of wavelength links" for each user ID, "discount" for each user ID, and "charge" for each user ID is integrated in a data format (4009) and stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) as charge information according to the number of node links used. The data is administrated by the administration part (3303) and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) of each user ID every month to show users their usage in the past and their due. Here, as a result of the removal from the ring topology to bypass a failure at the communication node (the administrative communication node number "4" and user communication node number "4"), the increase/decrease in number of communication nodes is "-1," the total

number of wavelength links is "6," and a new charge according the change in the total number of links is "F" (4010).

[0085]

Fig.41 shows user topology administrative information (4011) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Information regarding the user ID "1" is retrieved from the central control topology administrative information (4005) stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) and sent to the wavelength tunable light source unit (301-304) using control signals, whereby the user topology administrative information (3601) is held and stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Then, the user topology administrative information (4011) is administrated by the administration part (3105) within that wavelength tunable light source unit (301-304). Here, the number of node links at the user communication node number "4" is "0" because of the wavelength resetting after the removal of the failed communication node (the user communication node number "4").

[0086]

Fig.42 is an illustration showing the user topology administrative information (4011) graphically displayed to the user having a user ID "1" after it is given to the communication node administrative terminal (3201) by the display control part (3106) of the wavelength tunable light source unit (301-304). The display includes a topology diagram, communication nodes, connections in a user window (4013), where the failed node (4008) is removed.

[0087]

Fig.43 shows charge information (3913) stored in the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit (301-304) used by the user having a user ID "1." Information such as "month and year of the usage," "increase/decrease in number of communication nodes," "number of band speed-ups," "total number of wavelength links," "discount," and "charge" is integrated in a data format (3913). The items for the user ID "1" are retrieved from charge information according to the number of node links, which is stored in the internal database (2301) and external database (2401) connected to the central control unit (2001) every month, and given to the internal database (701-704) and external database (801-804) connected to the wavelength tunable light source unit belonging to the user ID "1" to show the user his/her usage in the past and due. Here, the total number of wavelength links of the user ID "1" is increased in May of 2003 because of failure bypassing. Then, the total number of wavelength links is decreased to 6 and, accordingly, the charge is charged (4014).

[0088]

[Embodiment 15]

When an increased traffic volume between specific communication nodes imposes a load on the network and the communication node administrative body of either one or both of the communication nodes makes a band speed-up request to the central control unit (2001), the band speed-up is performed as follows. Here, the wavelength tunable light source unit (301-304) is constituted as a physical gateway to transmit/receive control signals to/from the central control unit (2001).

[0089]

The central control unit (2001) determines the availability through calculation with reference to the internal database (2301) and external database (2401). If the band speed-up between the communication nodes is available by establishing a new wavelength bypass through some other communication node that are not directly connected to the communication nodes, the central control unit (2001) establishes a new wavelength path by informing the wavelength tunable light source units of the bypass communication nodes and the above specific communication nodes of wavelength resetting for establishing the new wavelength path between them and updates the data stored in the internal database (2301) and external database (2401).

[0090]

Then, with reference to the internal database (2301) and external database (2401), the central control unit (2001) calculates and records additional charge required for the new wavelength path, informs the administrative bodies of the communication nodes of the charge through the wavelength tunable light source units (301-304), calculates and records the reduction in charge of the communication nodes that have offered the wavelength path, and informs the administrative bodies of the communication nodes of the reduction in charge through the wavelength tunable light source units (301-304).

[0091]

[Embodiment 16]

When an increased traffic volume between specific communication nodes imposes a load on the network and the communication node administrative body of either one or both of the communication nodes makes a band speed-up request to the central control unit (2001), the band speed-up is performed as follows. Here, the wavelength tunable light source unit (301-304) is constituted as a physical gateway to transmit/receive control signals to/from the central control unit (2001).

[0092]

The central control unit (2001) determines the availability through calculation with reference to the internal database (2301) and external database (2401). If the band speed-up between the communication nodes is available by establishing a wavelength bypass using an idle wavelength of a communication node connected to another logical topology to which the communication nodes are not connected, the central control unit

(2001) establishes a new wavelength bypass by informing the wavelength tunable light source units of the bypass communication node and the above specific communication nodes of wavelength resetting for establishing the new wavelength bypass between them and updates the data stored in the internal database (2301) and external database (2401).

[0093]

Then, with reference to the internal database (2301) and external database (2401), the central control unit (2001) calculates and records additional charge required for the new wavelength path, informs the administrative bodies of the communication nodes of the charge through the wavelength tunable light source units (301-304), calculates and records the reduction in charge of the communication node that has offered the wavelength path, and informs the administrative body of the communication node of the reduction in charge through the wavelength tunable light source unit (301-304).

[0094]

As described above, the above embodiments realize a variable topology network system in which the topology monitoring, administration, and control is easily performed and charges to the topology users are clear.

[0095]

The above embodiments are only an embodiment of the present invention. Needless to say, the present invention is not restricted to the configurations of the above embodiments.

[0096]

[Effects of the Invention]

As described above, the present invention advantageously provides a variable arbitrary logical topology network system applicable to a local distributed iDC (Internet data center) or IX (Internet exchange) network and realized by an arrayed waveguide diffraction grating (AWG) wavelength routing function and wavelength tunable light sources mounted in communication nodes connected to the arrayed waveguide diffraction grating (AWG) wavelength routing function physically in a star shape via optical waveguides such as optical fibers, the system providing communication service for which the wavelength usage charge is increased or decreased according to addition of a new wavelength path or removal of an operating wavelength path in the course of a logical topology change and communication service in which band speed-up between specific communication nodes is realized by using an idle wavelength path from a communication node connected to another logical topology, additional charge for the usage of a new wavelength path in association with band speed-up is imposed, and, when the communication node that has offered the idle wavelength path belongs to a different administration body, reduction in wavelength path usage charge for the offered wavelength path is applied.

[Brief Description of the Drawings]

[Fig.1] An illustration showing a variable topology network system according to an embodiment of the present invention.

[Fig.2] A schematic diagram showing the wavelength tunable light source unit of an embodiment of the present invention.

[Fig.3] A schematic diagram showing the central control unit of an embodiment of the present invention

[Fig.4] An illustration showing the wavelength tunable light source information stored in the internal and external databases connected to a wavelength tunable light source unit of an embodiment of the present invention.

[Fig.5] An illustration showing the wavelength tunable light source information stored in the internal and external databases connected to the central control unit of an embodiment of the present invention.

[Fig.6] An illustration showing the central control topology administrative information for administrating multiple user IDs of an embodiment of the present invention.

[Fig.7] An illustration showing the topology administrative window and user information window of an embodiment of the present invention.

[Fig.8] An illustration showing the charge information calculated by the charge calculation part of an embodiment of the present invention.

[Fig.9] An illustration showing the user topology administrative information of the user having a user ID "1" of an embodiment of the present invention.

[Fig.10] An illustration showing the user information window of the user ID "1" of an embodiment of the present invention.

[Fig.11] An illustration showing the usage information of the user ID "1" of an embodiment of the present invention.

[Fig.12] An illustration showing the user topology administrative information of the user ID "2" of an embodiment of the present invention.

[Fig.13] An illustration showing the user information window of the user ID "2" of an embodiment of the present invention

[Fig.14] An illustration showing the usage information of the user ID "2" of an embodiment of the present invention.

[Fig.15] An illustration showing the central control topology administrative information of an embodiment of the present invention when a communication node is newly added to the user ID "1."

[Fig.16] An illustration showing the topology administrative window and user information window of an embodiment of the present invention when a communication node is newly added to the user ID "1."

[Fig.17] An illustration showing the charge information calculated by the charge calculation part of an embodiment of the present invention when a communication node is newly added to the user ID "1."

[Fig.18] An illustration showing the user topology administrative information of an embodiment of the present invention when a communication node is newly added to the

user ID "1."

[Fig.19] An illustration showing the user information window of the user ID "1" of an embodiment of the present invention when a communication node is newly added to the user ID "1."

[Fig.20] An illustration showing the usage information of the user ID "1" of an embodiment of the present invention when a communication node is newly added to the user ID "1."

[Fig.21] An illustration showing the central control topology administrative information of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.22] An illustration showing the topology administrative window and user information window of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.23] An illustration showing the charge information calculated by the charge calculation part of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.24] An illustration showing the user topology administrative information of the user ID "2" of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.25] An illustration showing the user information window of the user ID "2" of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.26] An illustration showing the usage information of the user ID "2" of an embodiment of the present invention when band speed-up is applied to the user ID "2."

[Fig.27] An illustration showing the central control topology administrative information of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.28] An illustration showing the topology administrative window and user information window of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.29] An illustration showing the charge information calculated by the charge calculation part of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.30] An illustration showing the user topology administrative information of the user ID "1" of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.31] An illustration showing the user information window of the user ID "1" of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.32] An illustration showing the usage information of the user ID "1" of an

embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.33] An illustration showing the usage information of the user ID "2" of an embodiment of the present invention when band speed-up is applied to the user ID "1."

[Fig.34] An illustration showing the central topology administrative information of an embodiment of the present invention when the user ID "1" has a ring topology.

[Fig.35] An illustration showing the topology administrative window and user information window of an embodiment of the present invention when the user ID "1" has a ring topology.

[Fig.36] An illustration showing the user administrative information of an embodiment of the present invention when the user ID "1" has a ring topology.

[Fig.37] An illustration showing the user information window of an embodiment of the present invention when the user ID "1" has a ring topology.

[Fig.38] An illustration showing the central topology administrative information of an embodiment of the present invention when a failure communication mode is removed.

[Fig.39] An illustration showing the topology administrative window and user information window of an embodiment of the present invention when a failure communication mode is removed.

[Fig.40] An illustration showing the charge calculated by the charge calculation part of an embodiment of the present invention when a failure communication mode is removed.

[Fig.41] An illustration showing the user administrative information of the user ID "1" of an embodiment of the present invention when a failure communication mode is removed.

[Fig.42] An illustration showing the user information window of the user ID "1" of an embodiment of the present invention when a failure communication mode is removed

[Fig.43] An illustration showing the usage information of the user ID "1" of an embodiment of the present invention when a failure communication mode is removed.

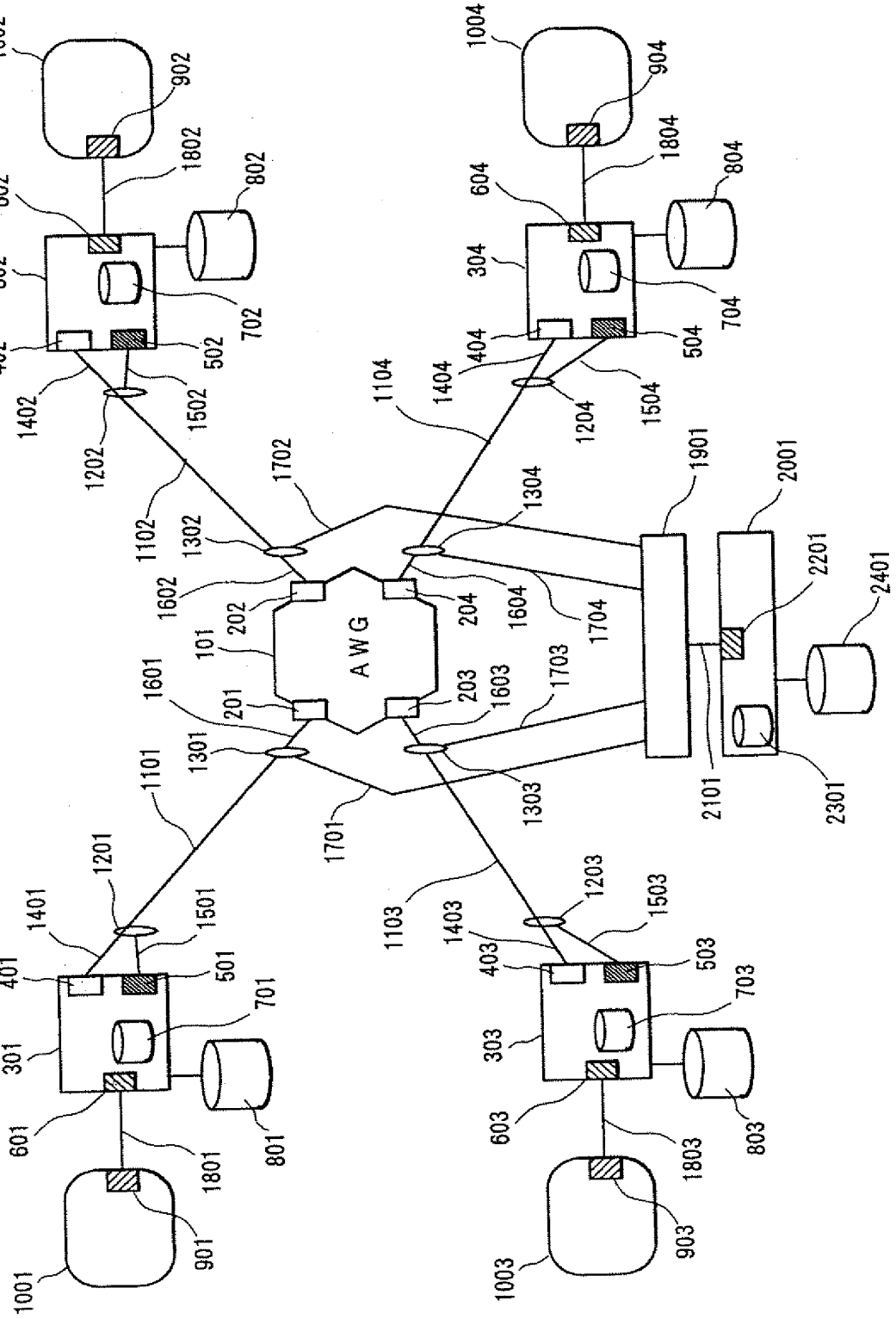
[Description of the Reference Symbols]

101 ... arrayed waveguide diffraction grating (AWG); 201-204 ... arrayed waveguide diffraction grating (AWG) optical input/output port; 301-304 ... wavelength tunable light source unit; 404-404 ... wavelength tunable light source unit WDM optical input/output port; 501-504 ... wavelength tunable light source unit control signal optical input/output port, 601-604 ... wavelength tunable light source unit communication node device optical input/output port; 701-704 ... wavelength tunable light source unit internal database; 801-804 ... wavelength tunable light source unit external database; 1001-1004 ... communication node; 1101-1104 ... optical waveguide such as optical fiber; 1201-1204 ... WDM filter; 1301-1304 ... WDM filter; 1401-1404 ... optical waveguide such as optical fiber; 1501-1504 ... optical waveguide such as optical fiber; 1601-1604 ...; optical waveguide such as optical fiber; 1701-1704 ... optical waveguide such as optical fiber; 1801-1804 ... optical

waveguide such as optical fiber; 1901-1904 ... control signal consolidator; 2001 ... central control unit; 2101 ...optical waveguide such as optical fiber; 2201 ...central control unit control signal input/output port; 2301 ... central control unit internal database; 2401 ... central control unit external database; 2501-2503 ... wavelength tunable light source; 2601-2603 ... optical receiver; 2701 ... N x N switch; 2702 ... 2N x 2N switch; 2801 ... optical coupler; 2901 ... DEMUX demultiplexer; 3001-3006 ... optical-electric converter; 3101 ... wavelength tunable light source control part; 3102 ... monitoring part; 3103 ... switch control part; 3104 ... control signal transmission/reception part; 3105 ... administration part; 3106 ... display control part ; 3107 ... control part;; 3201 ... communication node administrator terminal; 3202 ... communication node administrator; 3301 ... control signal transmission/reception part; 3302 ... monitoring part; 3303 ... administration part; 3304 ... display control part; 3305 ... charge calculation part; 3306 ...control part; 3401 ... topology administrator terminal; 3402 ...topology administrator; 3501 ... wavelength tunable light source information held by each wavelength tunable light source; 3502 ...wavelength tunable light source information held by the central control unit; 3601 ... central control topology administrative information; 3602 ... topology administrative window and user information window; 3605 ... charge information calculated by the charge calculation part of the central control unit; 3606 ... user topology administrative information of the user ID "1"; 3607 ... user information window of the user ID "1"; 3608 ... usage information of the user ID "1"; 3609 ...user topology administrative information of the user ID "2"; 3610 ... user information window of the user ID "2"; 3611 ... usage information of the user ID "2"; 3701 ... central control topology information when the user ID "1" has a new communication node; 3702 ... topology administrative window and user information window when the user ID "1" has a new communication node; 3703 ... user ID "1" charge information calculated by the calculation part of the central control unit; 3704 ... user ID "1" user topology administrative information; 3705 ...user information window when the user ID "1" has a new communication node; 3706-3707 ... new wavelength path when the user ID "1" has a new communication node; 3708 ... user information of the user ID "1"; 3709 ... usage information of the user ID "1"; 3710 ... changed usage information of the user ID "1"; 3801 ... central control topology administrative information; 3802 ... update of central topology administrative information due to a new wavelength path; 3803 ... user information window of the user ID "2"; 3804 ... graphical display of a new wavelength path; 3805 ... charge information calculated by the charge calculation part of the central control unit; 3806 ... changed charge in association with increase in wavelength path; 3807 ... user topology information of the user ID "2"; 3808 ... change in user topology administrative information of the user ID "2" due to a new wavelength path; 3809 ... user information window of the user ID "2"; 3810 ... graphical display of a new wavelength path; 3811 ... usage information of the user ID "2"; 3812 ... update of usage information due to a new wavelength pass; 3901 ... central

control topology administrative information; 3902 ... change in central control topology administrative information due to a new wavelength path; 3903 ... user information window of the user ID "1"; 3904 ... user information window of the user ID "2"; 3905 ...graphical display of a new wavelength path; 3906 ...charge information calculated by the charge calculation part of the central control unit; 3907 ... additional charge to the user ID "1" due to a new wavelength path; 3908 ... discount and new charge to the user ID "2" due to loan of a wavelength path; 3909 ... user topology administrative information of the user ID "1"; 3910 ... change in user administrative information of the user ID "1" dues to a new wavelength path; 3911 ... user information window of the user ID "1"; 3912 ...graphical display of a new wavelength path; 3913 ... usage information of the user ID "1"; 3914 ...change in usage information of the user ID "1"; 3915 ...usage information of the user ID "2"; 3916 ...change in usage information of the user ID "2"; 4001 ... central control topology administrative information; 4002 ... user information window; 4003 ...usage administrative information of the user ID "1"; 4004 ... user information window of the user ID "1"; 4005 ...central control topology administrative information; 4006 ...change in central control topology administrative information; 4007 ... user information window of the user ID "1"; 4008 ... failure communication node; 4009 ... charge calculated by the charge calculation part of the central control unit; 4010 ... change in charge; 4011 ... user administrative information of the user ID "1"; 4012 ...change in user administrative information of the user ID "1"; 4013 ... user information window of the user ID "1"; 4014 ... usage information of the user ID "1"; and 4015 ... change in usage information of the user ID "1".

FIG. 1


AWG
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1804
1901
2001
2101
2201
2301
2401

FIG. 2

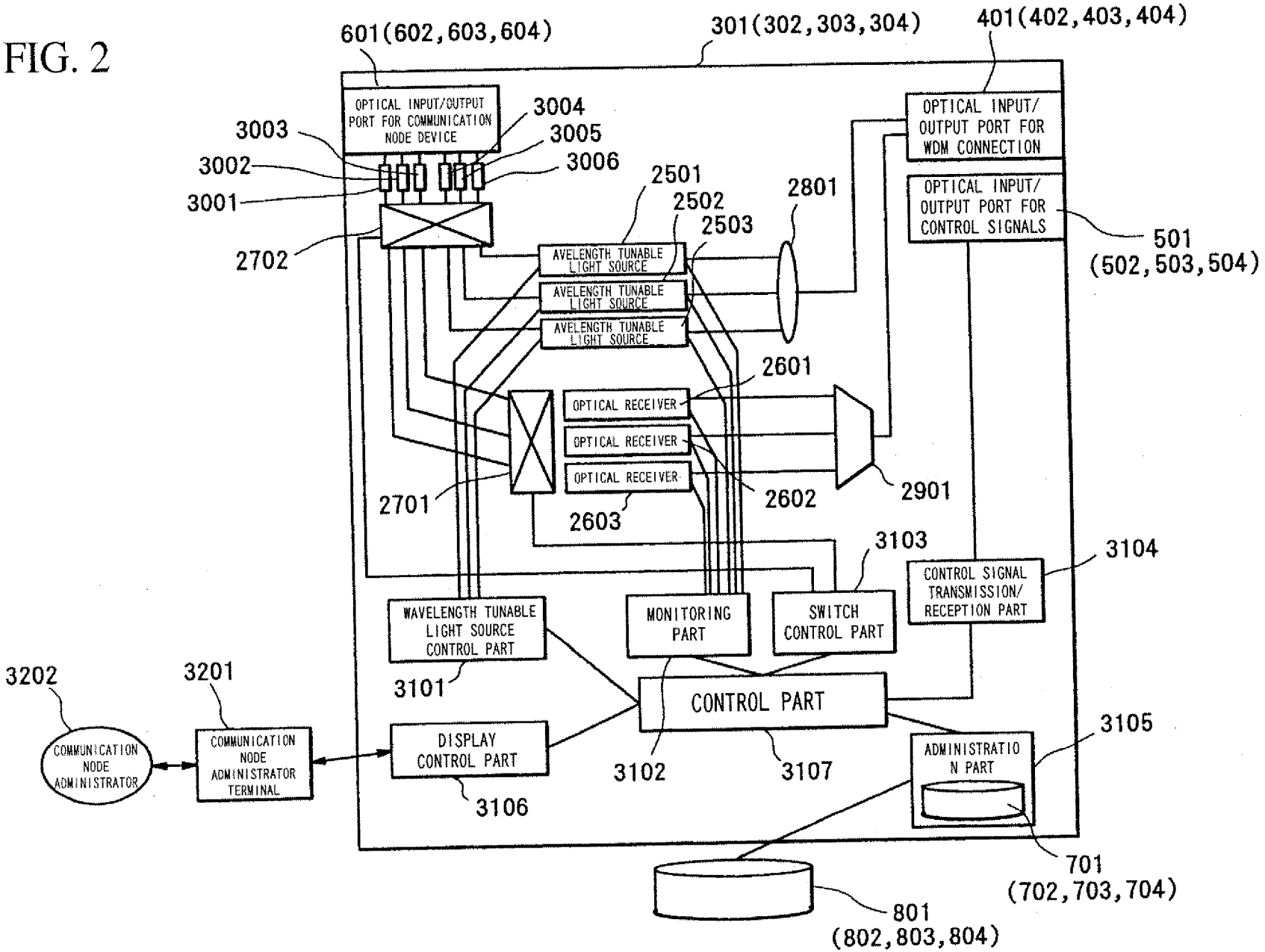

601(602,603,604)
301(302,303,304)
401(402,403,404)
OPTICAL INPUT/OUTPUT PORT FOR COMMUNICATION NODE DEVICE
3003
3004
3005
3002
3006
3001
2501
2502
2503
2801
2702
AVELENGTH TUNABLE LIGHT SOURCE
AVELENGTH TUNABLE LIGHT SOURCE
AVELENGTH TUNABLE LIGHT SOURCE
OPTICAL INPUT/ OUTPUT PORT FOR WDM CONNECTION
OPTICAL INPUT/ OUTPUT PORT FOR CONTROL SIGNALS
501 (502,503,504)
2601
OPTICAL RECEIVER
OPTICAL RECEIVER
OPTICAL RECEIVER
2701
2602
2901
2603
3103
3104
CONTROL SIGNAL TRANSMISSION/ RECEPTION PART
WAVELENGTH TUNABLE LIGHT SOURCE CONTROL PART
MONITORING PART
SWITCH CONTROL PART
3101
CONTROL PART
3202
3201
COMMUNICATION NODE ADMINISTRATOR
COMMUNICATION NODE ADMINISTRATOR TERMINAL
DISPLAY CONTROL PART
3105
ADMINISTRATIO N PART
3102
3107
3106
701 (702,703,704)
801 (802,803,804)

FIG. 3

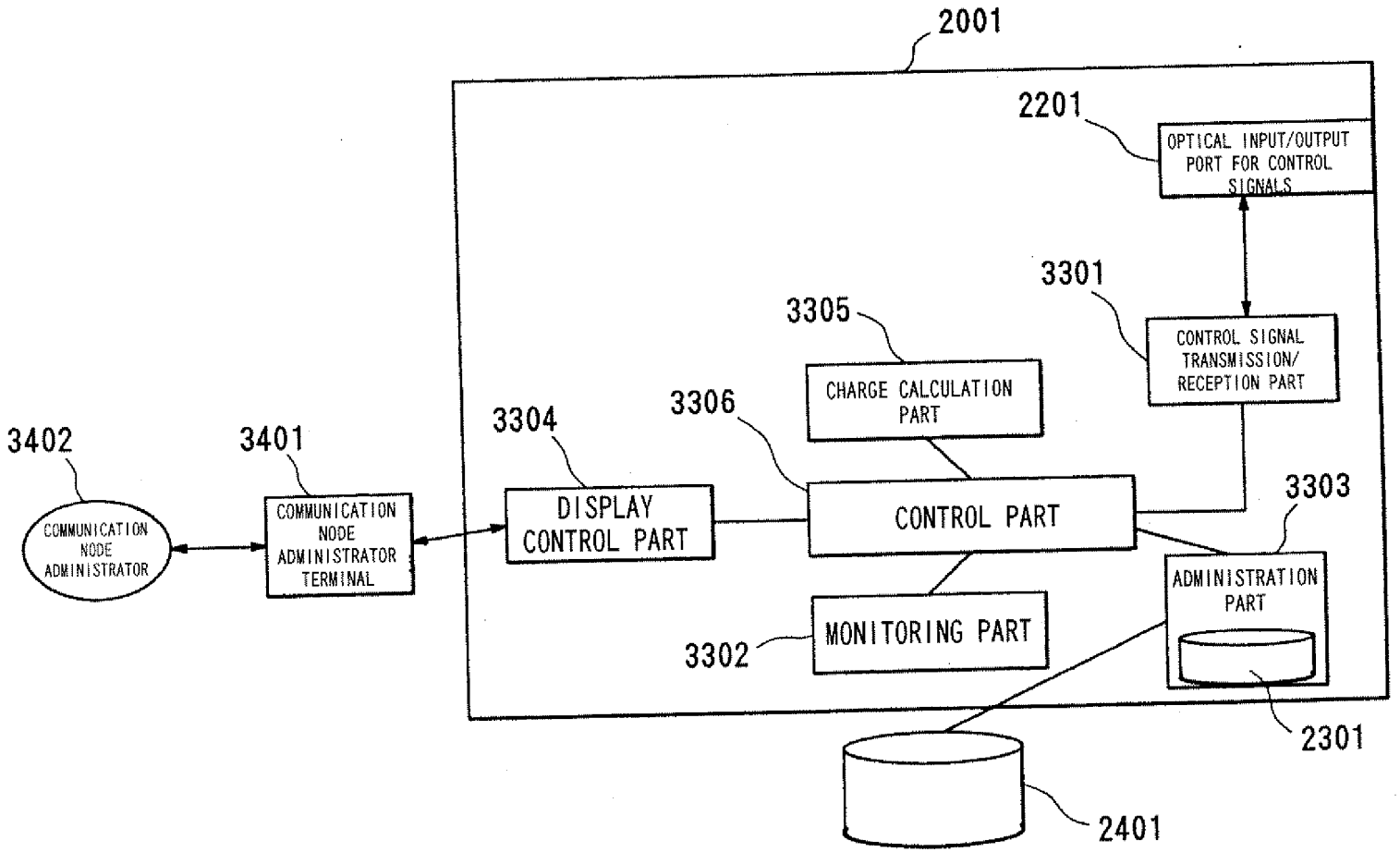

2001
2201
OPTICAL INPUT/OUTPUT PORT FOR CONTROL SIGNALS
3301
CONTROL SIGNAL TRANSMISSION/ RECEPTION PART
3305
CHARGE CALCULATION PART
3306
3304
3402
3401
COMMUNICATION NODE ADMINISTRATOR
COMMUNICATION NODE ADMINISTRATOR TERMINAL
DISPLAY CONTROL PART
CONTROL PART
3303
ADMINISTRATION PART
3302
MONITORING PART
2301
2401

FIG. 4

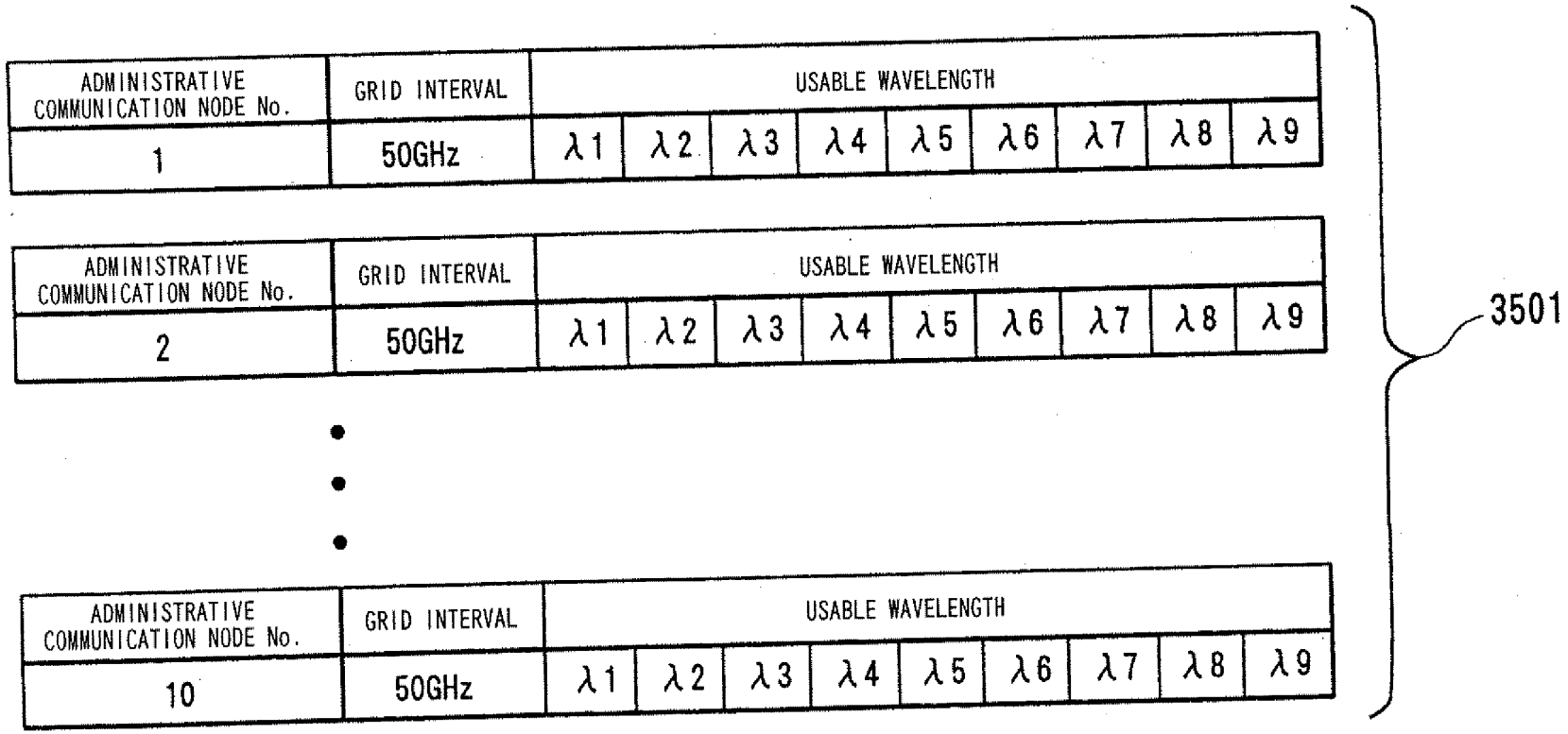

ADMINISTRATIVE COMMUNICATION NODE No.
GRID INTERVAL
USABLE WAVELENGTH
1
50GHz
λ1 λ2 λ3 λ4 λ5 λ6 λ7 λ8 λ9
ADMINISTRATIVE COMMUNICATION NODE No.
GRID INTERVAL
USABLE WAVELENGTH
2
50GHz
λ1 λ2 λ3 λ4 λ5 λ6 λ7 λ8 λ9
ADMINISTRATIVE COMMUNICATION NODE No.
GRID INTERVAL
USABLE WAVELENGTH
10
50GHz
λ1 λ2 λ3 λ4 λ5 λ6 λ7 λ8 λ9
3501

FIG. 5

3502

ADMINISTRATIVE COMMUNICATION NODE No.	GRID INTERVAL	USABLE WAVELENGTH								
1	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
2	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
3	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
4	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
5	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
6	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
7	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
8	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
9	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9
10	50GHz	λ1	λ2	λ3	λ4	λ5	λ6	λ7	λ8	λ9

FIG. 6

3601

TOPOLOGY TYPE	MESH			MESH			MESH			MESH			RING		RING		RING, STAR					STAR	STAR	STAR
ADMINISTRATIVE COMMUNICATION NODE No.	1			2			3			4			5		6		7					8	9	10
USER COMMUNICATION NODE No.	1			2			3			4			1		2		3					4	5	6
USER ID	1			1			1			1			2		2		2					2	2	2
OPERATING WAVELENGTH	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2	λ2
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4	4	1	2	3	1	2	7	6	5	7	6	5	8	9	10	7	7	7
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			3			3			3			2		2		5					1	1	1
LINK BAND SPEED-UP																								
SPEED-UP PERIOD																								

FIG. 7

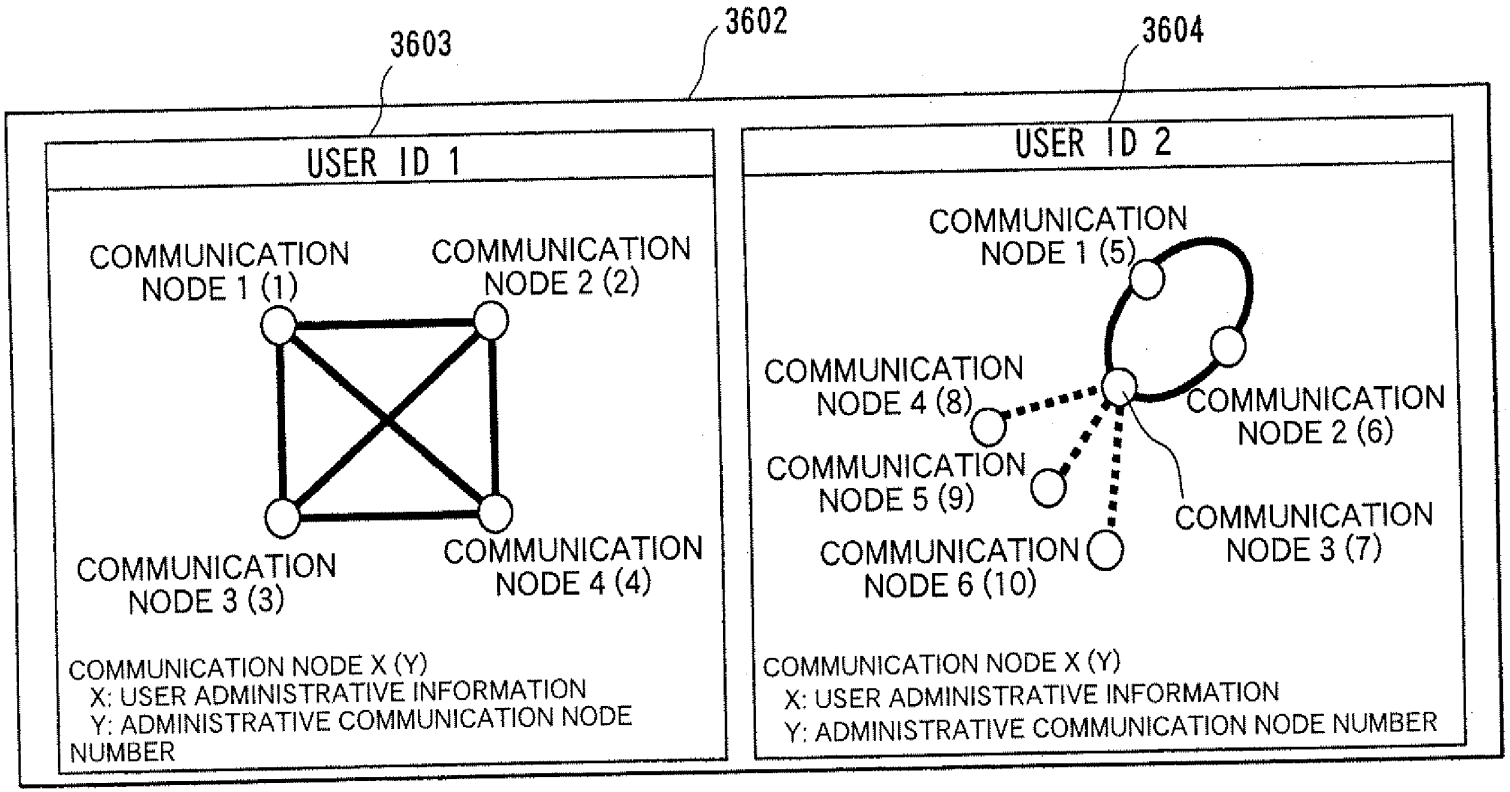

3603
3602
3604
USER ID 1
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER
USER ID 2
COMMUNICATION NODE 1 (5)
COMMUNICATION NODE 4 (8)
COMMUNICATION NODE 2 (6)
COMMUNICATION NODE 5 (9)
COMMUNICATION NODE 3 (7)
COMMUNICATION NODE 6 (10)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER

FIG. 8

3605

USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
1	2003.01	0	0	12	0	A
1	2003.02	0	0	12	0	A
1	2003.03	0	0	12	0	A
1	2003.04	0	0	12	0	A
1	2003.05	0	0	12	0	A
2	2003.01	0	0	12	0	A
2	2003.02	0	0	12	0	A
2	2003.03	0	0	12	0	A
2	2003.04	0	0	12	0	A
2	2003.05	0	0	12	0	A

FIG. 9

3606

TOPOLOGY TYPE	MESH			MESH			MESH			MESH		
USER COMMUNICATION NODE No.	1			2			3			4		
OPERATING WAVELENGTH	λ2	λ3	λ4	λ3	λ4	λ1	λ4	λ1	λ2	λ1	λ2	λ3
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4	4	1	2	3	1	2
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			3			3			3		
LINK BAND SPEED-UP												
SPEED-UP PERIOD												

FIG. 10

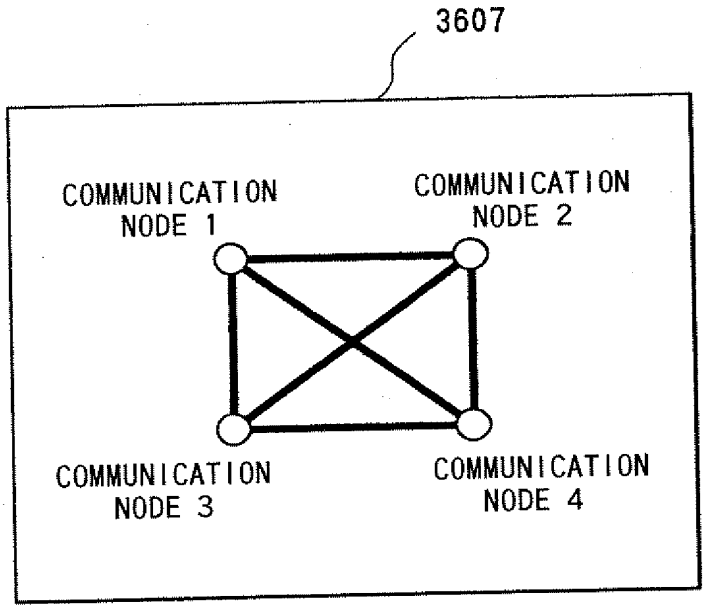

3607
COMMUNICATION NODE 1
COMMUNICATION NODE 2
COMMUNICATION NODE 3
COMMUNICATION NODE 4

FIG. 11

3608

USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
1	2003.01	0	0	12	0	A
1	2003.02	0	0	12	0	A
1	2003.03	0	0	12	0	A
1	2003.04	0	0	12	0	A
1	2003.05	0	0	12	0	A

FIG. 12

3609

TOPOLOGY TYPE	RING		RING		RING, STAR					STAR	STAR	STAR
USER COMMUNICATION NODE No.	1		2		3					4	5	6
OPERATING WAVELENGTH	λa	λb	λb	λc	λc	λa	λd	λe	λf	λd	λe	λf
COUNTER-POSED COMMUNICATION NODE No.	3	2	1	3	2	1	4	5	6	3	3	3
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	2		2		5					1	1	1
LINK BAND SPEED-UP												
SPEED-UP PERIOD												

FIG. 13

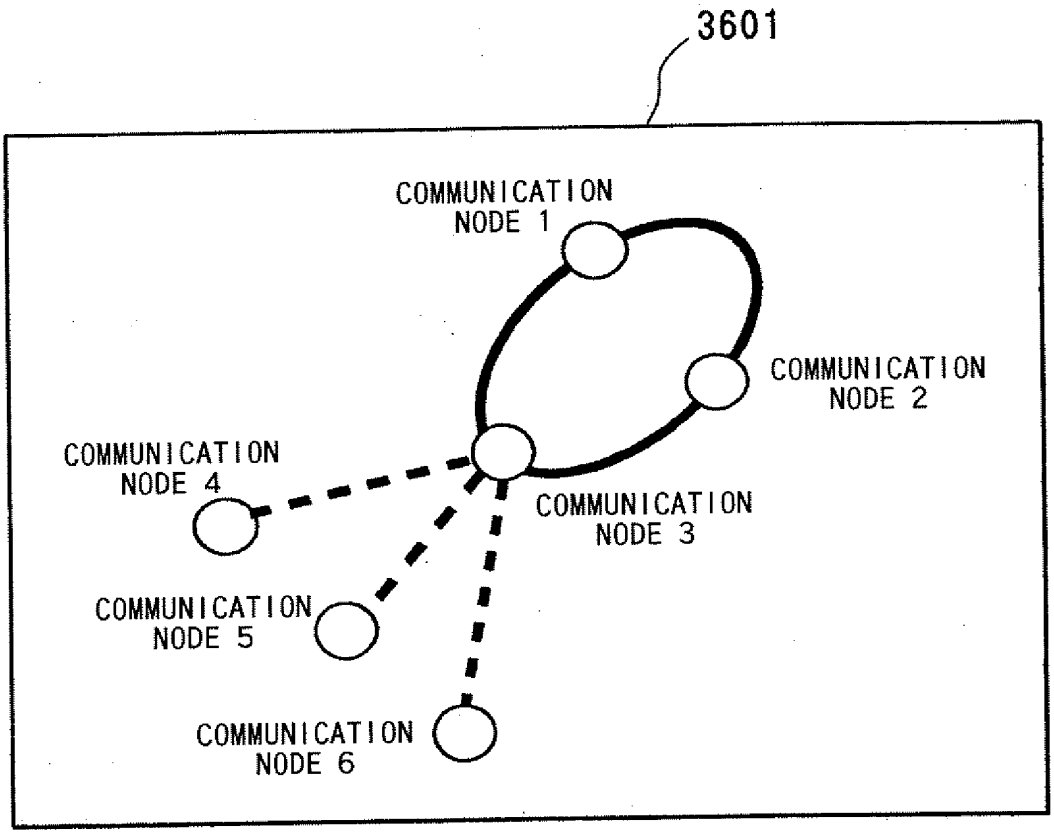

3601
COMMUNICATION NODE 1
COMMUNICATION NODE 2
COMMUNICATION NODE 3
COMMUNICATION NODE 4
COMMUNICATION NODE 5
COMMUNICATION NODE 6

FIG. 14

3611

USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
2	2003.01	0	0	12	0	A
2	2003.02	0	0	12	0	A
2	2003.03	0	0	12	0	A
2	2003.04	0	0	12	0	A
2	2003.05	0	0	12	0	A

FIG. 15

3701

TOPOLOGY TYPE	MESH			MESH, STAR				MESH			MESH, STAR			
ADMINISTRATIVE COMMUNICATION NODE No.	1			2				3			4			
USER COMMUNICATION NODE No.	1			2				3			4			
USER ID	1			1				1			1			
OPERATING WAVELENGTH	λ2	λ3	λ4	λ3	λ4	λ1	λh	λ4	λ1	λ2	λ1	λ2	λ3	λi
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4	11	4	1	2	3	1	2	11
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			4				3			4			
LINK BAND SPEED-UP														
SPEED-UP PERIOD														

STAR	RING	RING	RING, STAR	STAR	STAR	STAR
11	6	7	7	8	9	10
5	2	3	3	4	5	6
1	2	2	2	2	2	2
λh	λi	λa	λb	λb	λc	λc	λa	λd	λe	λf	λd	λe	λf
2	4	7	6	5	7	7	5	8	9	10	7	7	7
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
2		2		2		5					1	1	1

FIG. 16

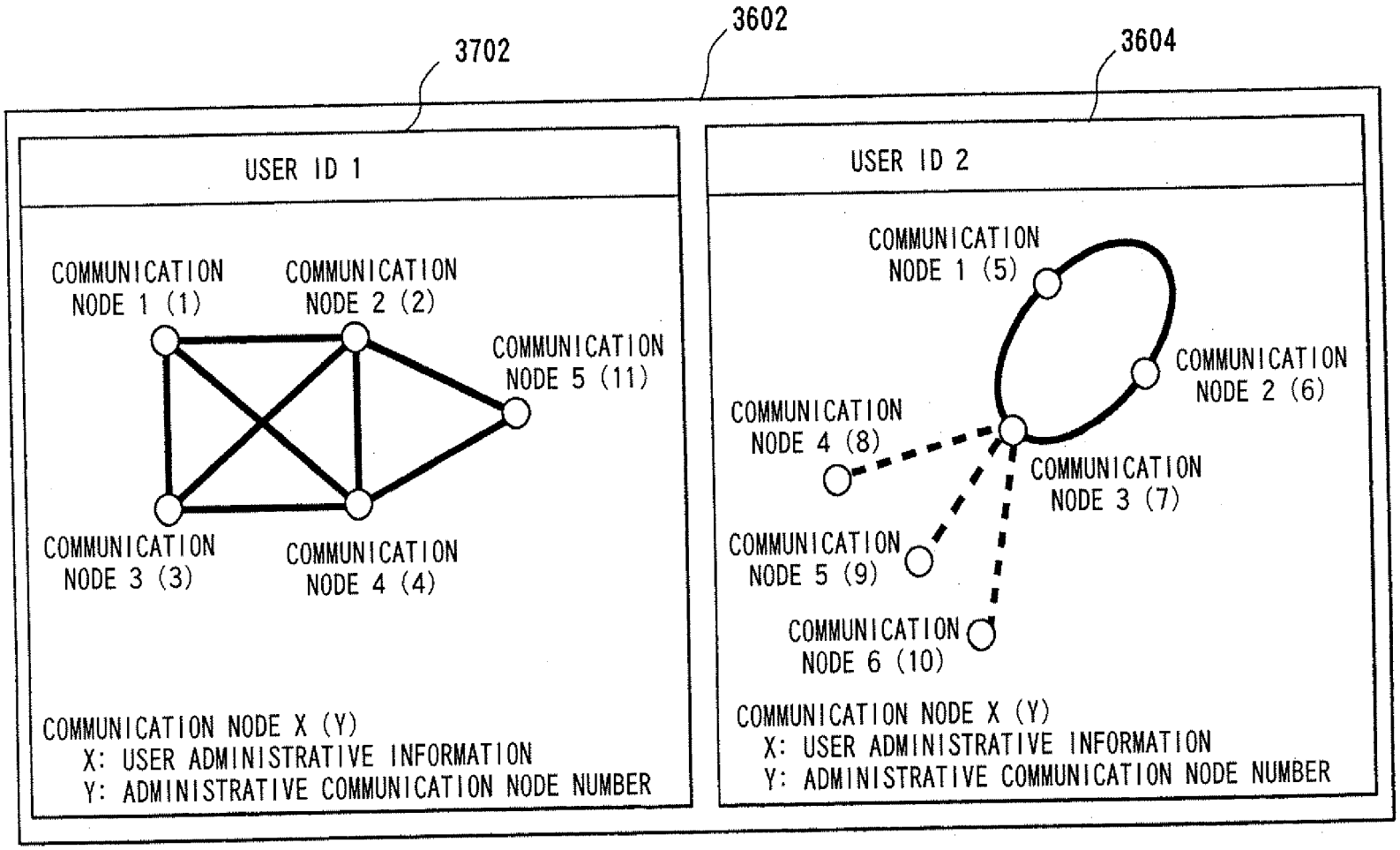
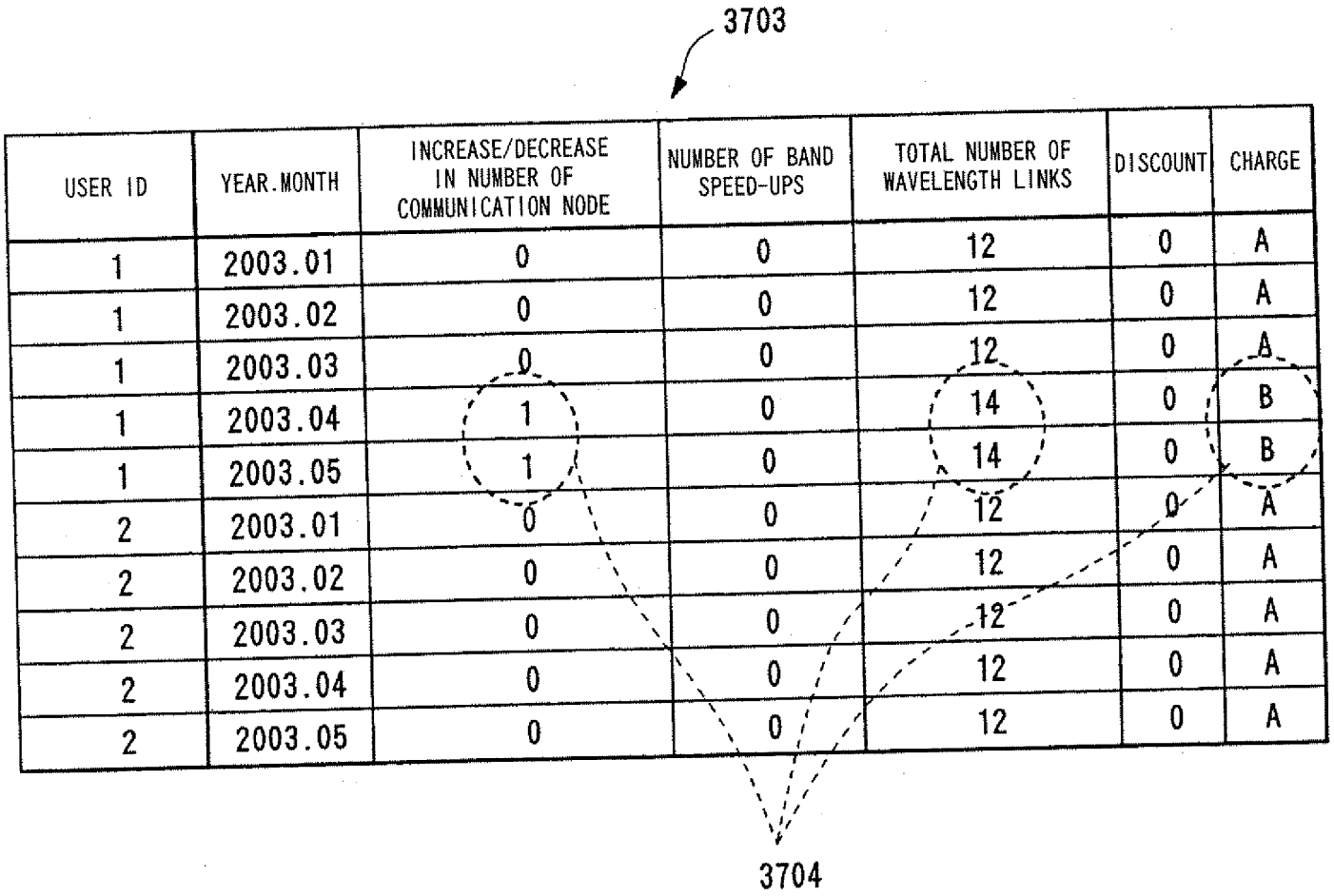
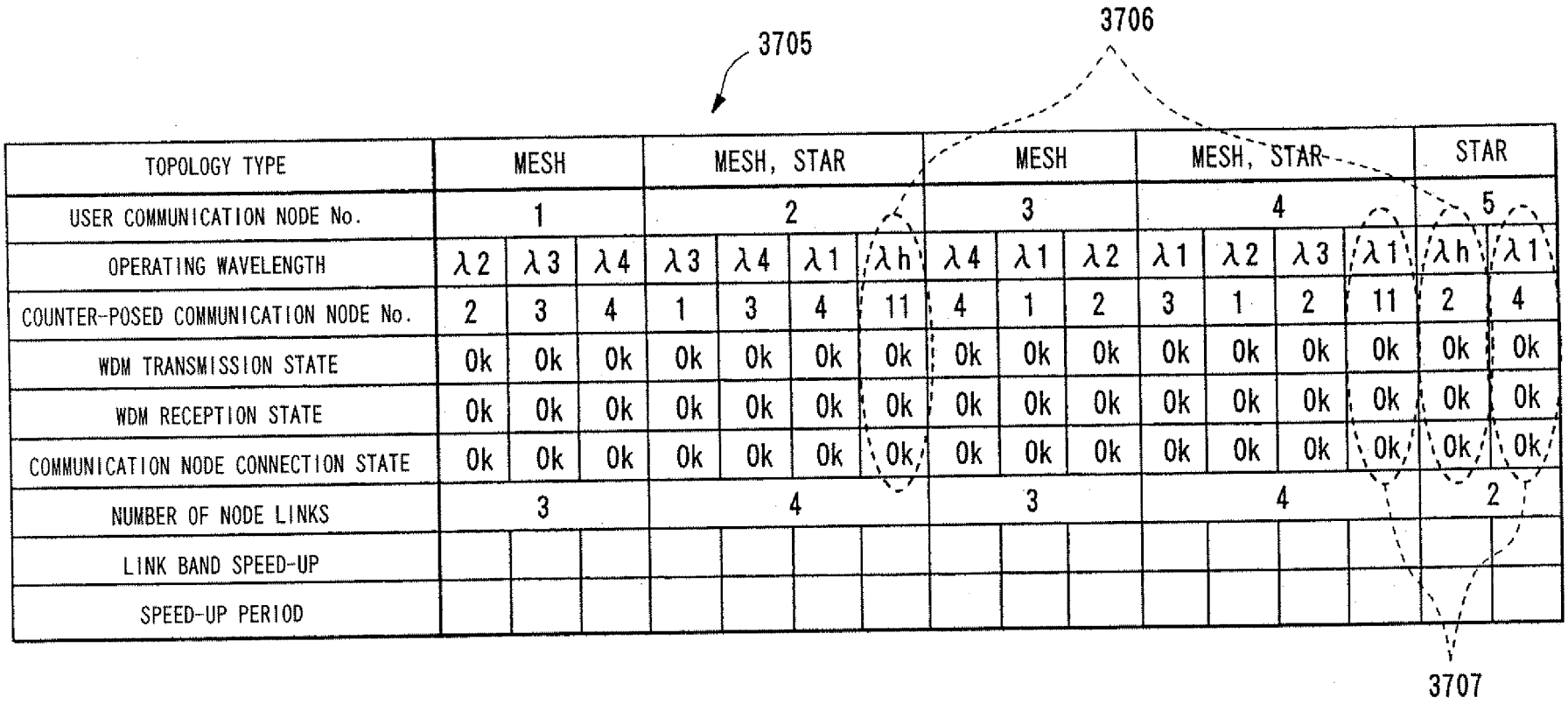

3602
3702
3604
USER ID 1
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 5 (11)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER
USER ID 2
COMMUNICATION NODE 1 (5)
COMMUNICATION NODE 2 (6)
COMMUNICATION NODE 4 (8)
COMMUNICATION NODE 3 (7)
COMMUNICATION NODE 5 (9)
COMMUNICATION NODE 6 (10)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER

FIG. 17



USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
1	2003.01	0	0	12	0	A
1	2003.02	0	0	12	0	A
1	2003.03	0	0	12	0	A
1	2003.04	1	0	14	0	B
1	2003.05	1	0	14	0	B
2	2003.01	0	0	12	0	A
2	2003.02	0	0	12	0	A
2	2003.03	0	0	12	0	A
2	2003.04	0	0	12	0	A
2	2003.05	0	0	12	0	A

FIG. 18



TOPOLOGY TYPE	MESH			MESH, STAR				MESH			MESH, STAR				STAR	
USER COMMUNICATION NODE No.	1			2				3			4				5	
OPERATING WAVELENGTH	λ2	λ3	λ4	λ3	λ4	λ1	λh	λ4	λ1	λ2	λ1	λ2	λ3	λ1	λh	λ1
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4	11	4	1	2	3	1	2	11	2	4
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			4				3			4				2	
LINK BAND SPEED-UP																
SPEED-UP PERIOD																

FIG. 19

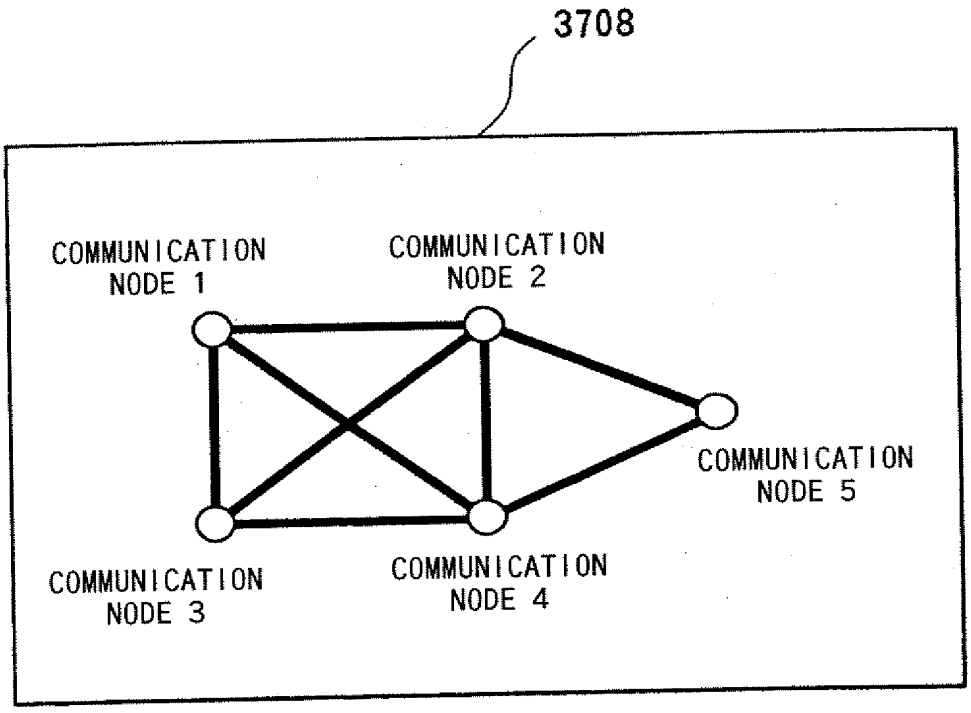

3708
COMMUNICATION NODE 1
COMMUNICATION NODE 2
COMMUNICATION NODE 5
COMMUNICATION NODE 3
COMMUNICATION NODE 4

FIG. 20

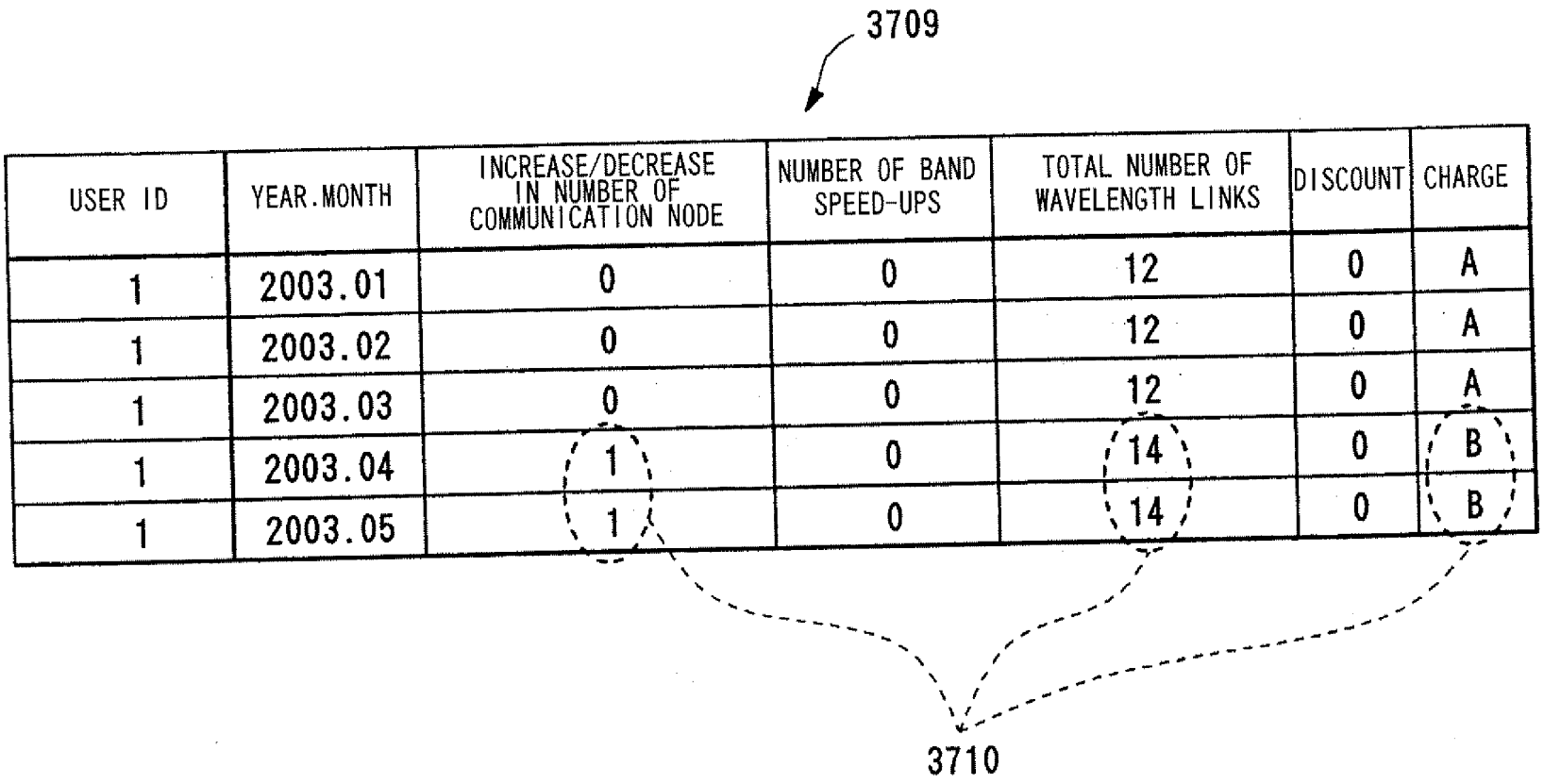

3709
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
1 2003.01 0 0 12 0 A
1 2003.02 0 0 12 0 A
1 2003.03 0 0 12 0 A
1 2003.04 1 0 14 0 B
1 2003.05 1 0 14 0 B
3710

FIG. 21

3801

TOPOLOGY TYPE	MESH			MESH			MESH			MESH		
ADMINISTRATIVE COMMUNICATION NODE No.	1			2			3			4		
USER COMMUNICATION NODE No.	1			2			3			4		
USER ID	1			1			1			1		
OPERATING WAVELENGTH	λ2	λ3	λ4	λ3	λ4	λ1	λ4	λ1	λ2	λ1	λ2	λ3
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4	4	1	2	3	1	2
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			3			3			3		
LINK BAND SPEED-UP												
SPEED-UP PERIOD												

SPEED-UP

SPEED-UP

SPEED-UP

MESH			RING			RING					STAR			STAR	STAR
5			6			7					8			9	10
1			2			3					4			5	6
1			2			2					2			2	2
λa	λb	λk	λb	λc	λl	λc	λa	λd	λe	λf	λd	λk	λl	λe	λf
7	6	8	5	7	8	6	5	8	9	10	6	5	8	7	7
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
3			3			5					3			1	1

SPEED-UP

ONE MONTH

SPEED-UP

ONE MONTH

SPEED-UP

ONE MONTH

3802

FIG. 22

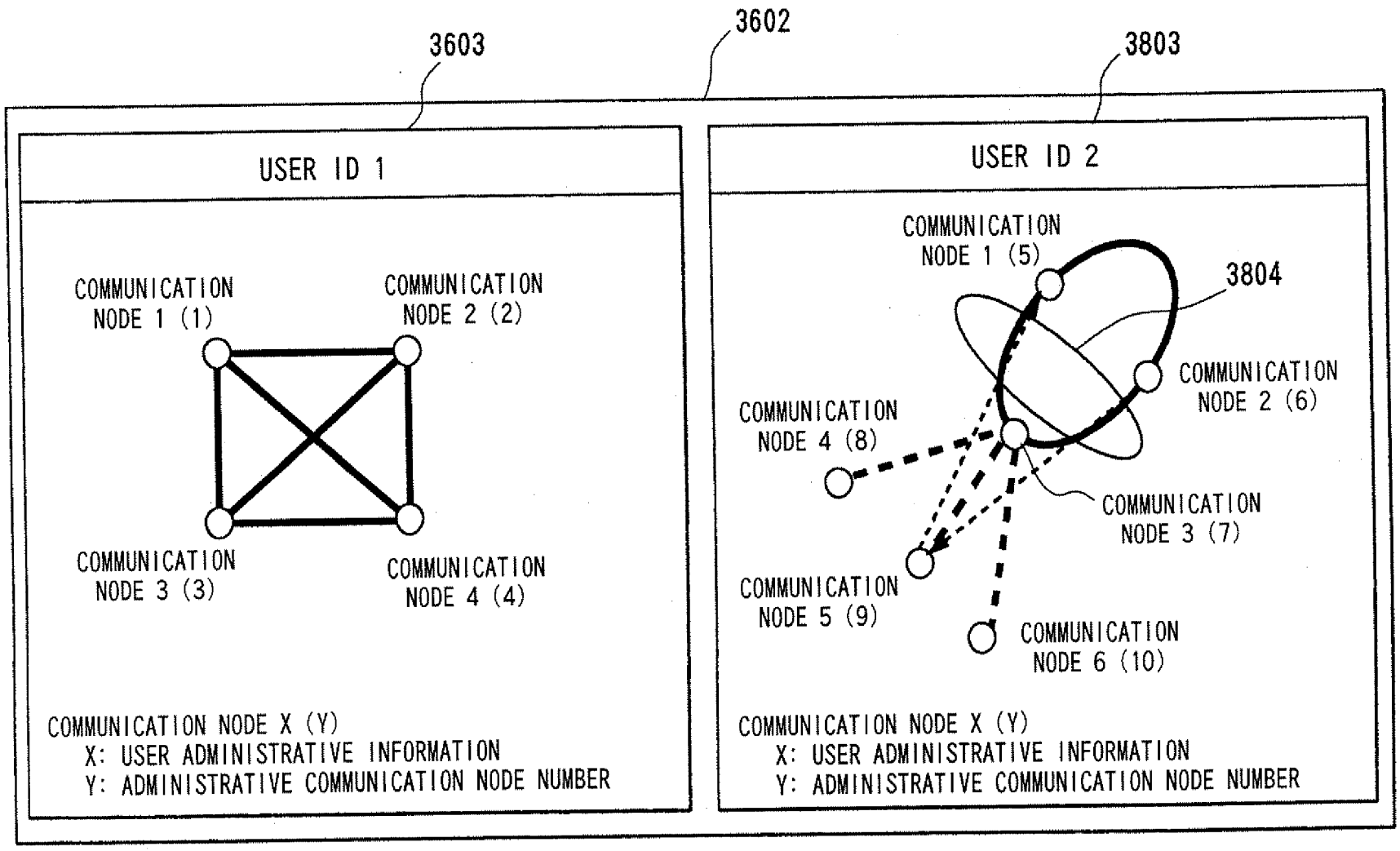

3602
3603
3803
USER ID 1
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER
USER ID 2
COMMUNICATION NODE 1 (5)
3804
COMMUNICATION NODE 2 (6)
COMMUNICATION NODE 4 (8)
COMMUNICATION NODE 3 (7)
COMMUNICATION NODE 5 (9)
COMMUNICATION NODE 6 (10)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER

FIG. 23

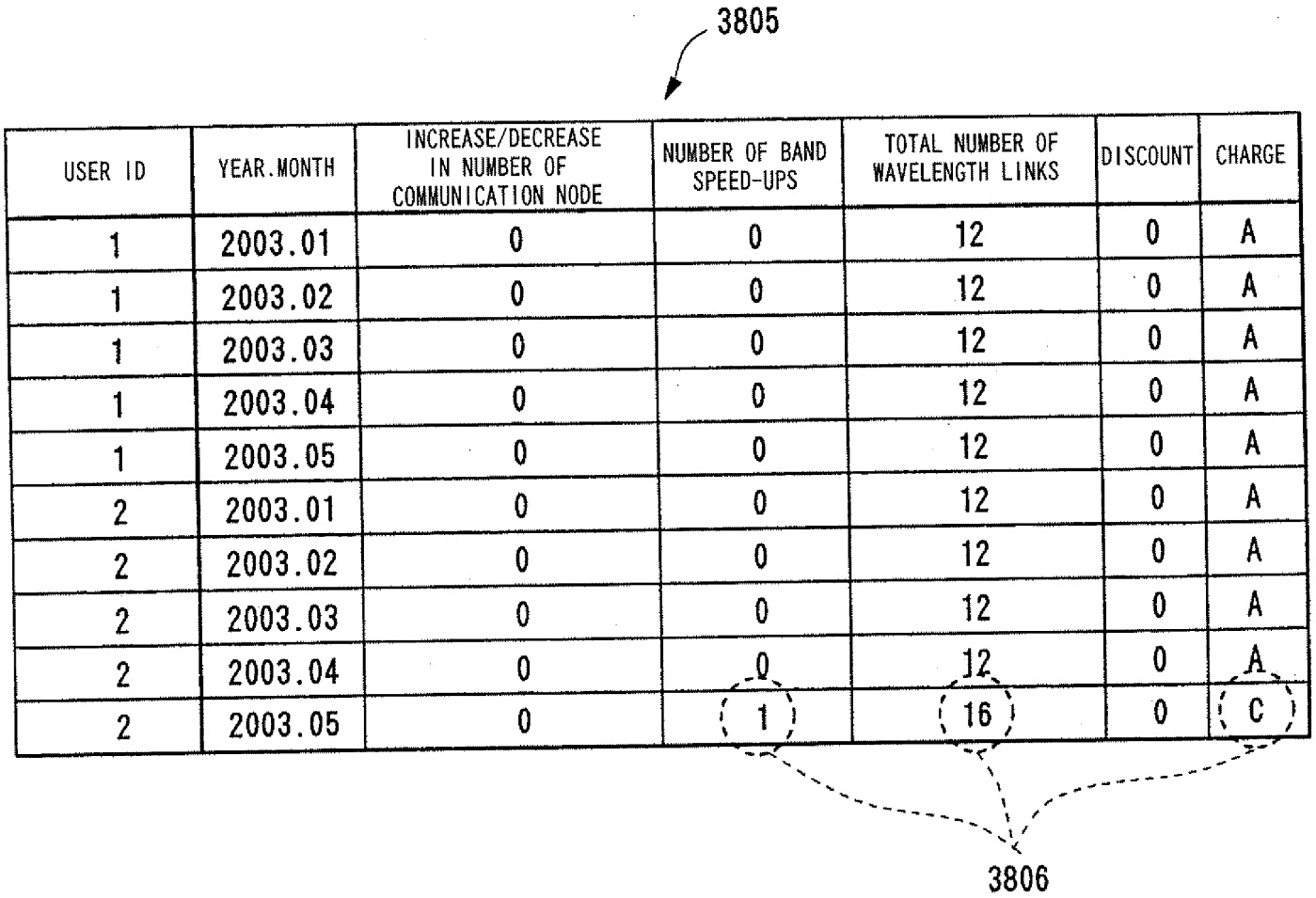
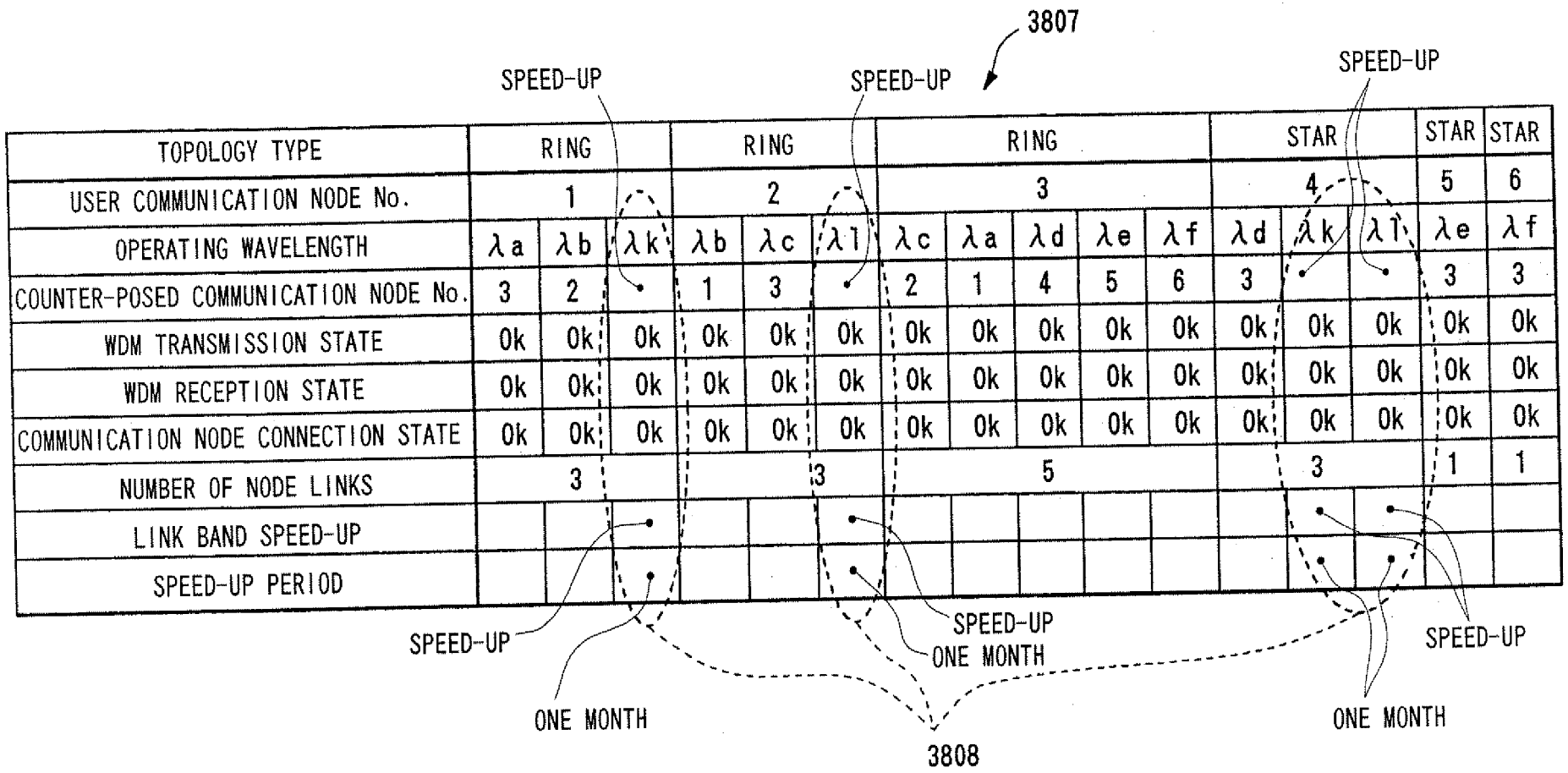

3805
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
1 2003.01 0 0 12 0 A
1 2003.02 0 0 12 0 A
1 2003.03 0 0 12 0 A
1 2003.04 0 0 12 0 A
1 2003.05 0 0 12 0 A
2 2003.01 0 0 12 0 A
2 2003.02 0 0 12 0 A
2 2003.03 0 0 12 0 A
2 2003.04 0 0 12 0 A
2 2003.05 0 1 16 0 C
3806

FIG. 24



TOPOLOGY TYPE	RING			RING			RING					STAR			STAR	STAR
USER COMMUNICATION NODE No.	1			2			3					4			5	6
OPERATING WAVELENGTH	λa	λb	λk	λb	λc	λl	λc	λa	λd	λe	λf	λd	λk	λl	λe	λf
COUNTER-POSED COMMUNICATION NODE No.	3	2		1	3		2	1	4	5	6	3			3	3
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			3			5					3			1	1
LINK BAND SPEED-UP																
SPEED-UP PERIOD																

FIG. 25

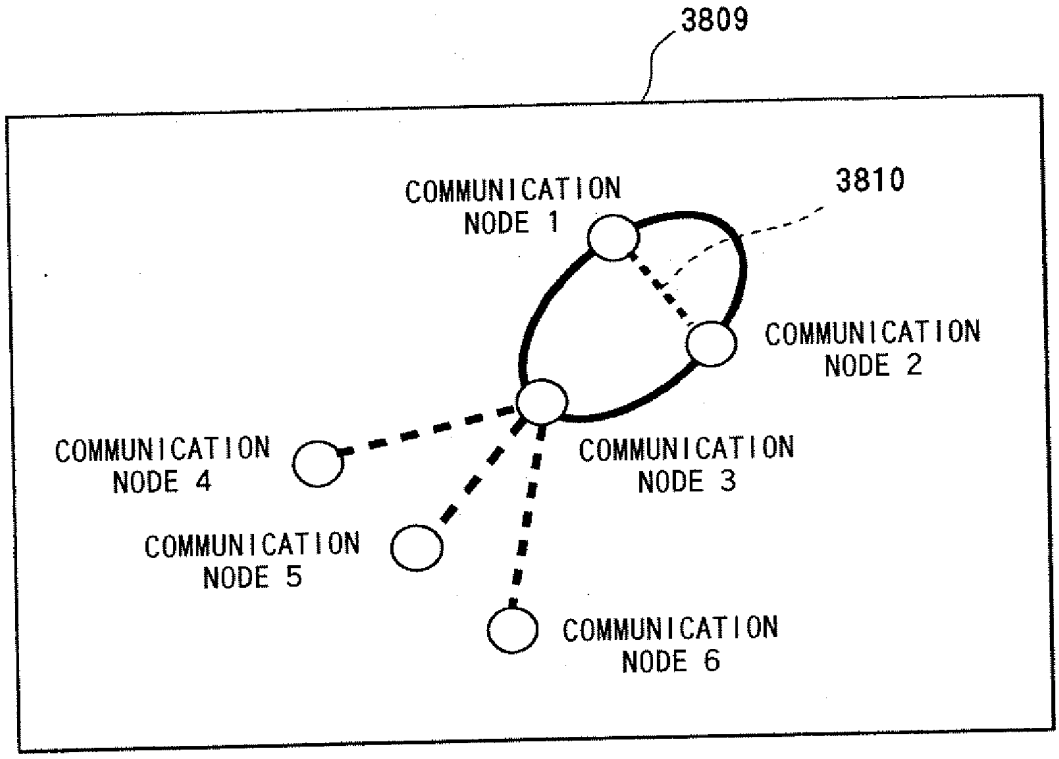

3809
3810
COMMUNICATION NODE 1
COMMUNICATION NODE 2
COMMUNICATION NODE 3
COMMUNICATION NODE 4
COMMUNICATION NODE 5
COMMUNICATION NODE 6

FIG. 26

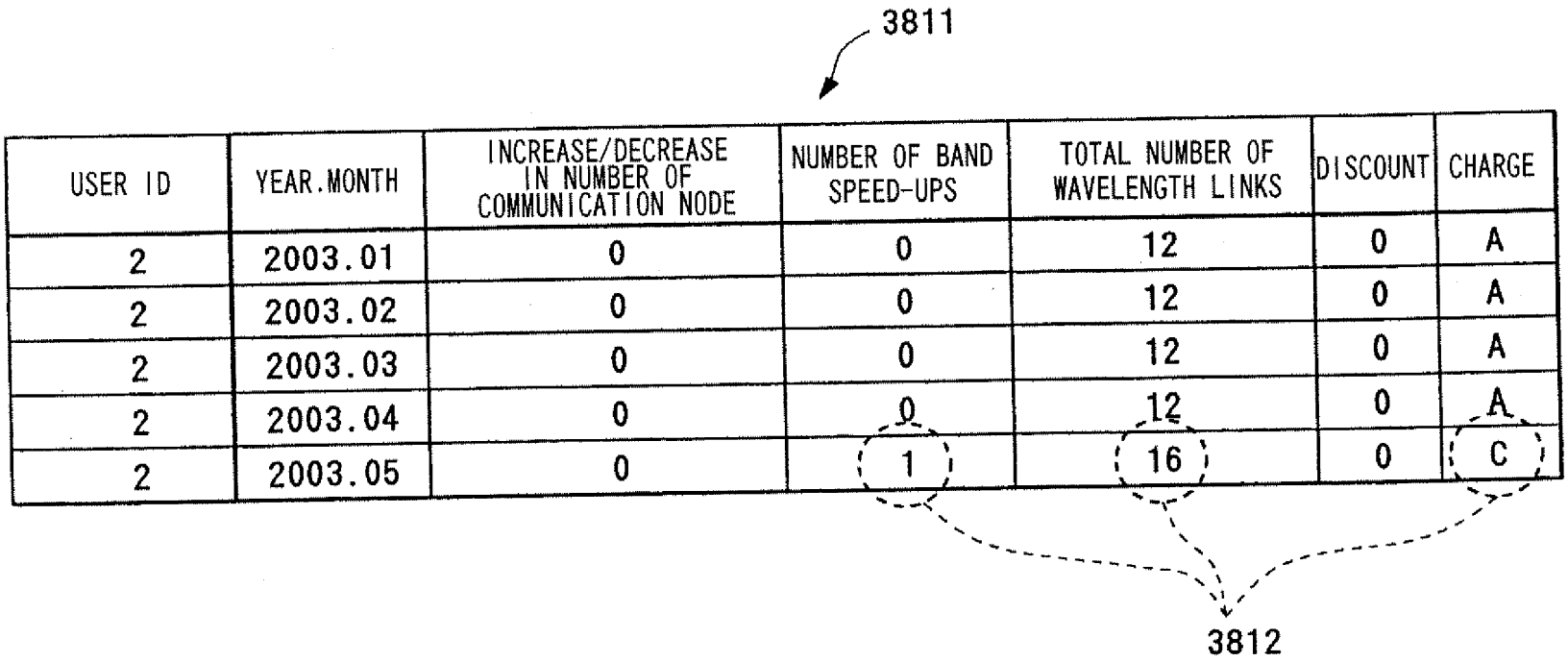

3811
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
2 2003.01 0 0 12 0 A
2 2003.02 0 0 12 0 A
2 2003.03 0 0 12 0 A
2 2003.04 0 0 12 0 A
2 2003.05 0 1 16 0 C
3812

FIG. 27

TOPOLOGY TYPE	MESH		
ADMINISTRATIVE COMMUNICATION NODE No.	1		
USER COMMUNICATION NODE No.	1		
USER ID	1		
OPERATING WAVELENGTH	λ2	λ3	λ4
COUNTER-POSED COMMUNICATION NODE No.	2	3	4
WDM TRANSMISSION STATE	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok
NUMBER OF NODE LINKS	3		
LINK BAND SPEED-UP			
SPEED-UP PERIOD			

3901

MESH				MESH			MESH				MESH		RING		RING, STAR					STAR			STAR	STAR
2				3			4				5		6		7					8			9	10
2				3			4				1		2		3					4			5	6
1				1			1			1	2		2		2					2	1		2	2
λ3	λ4	λ1	λj	λ4	λ1	λ2	λ1	λ2	λ3	λk	λa	λb	λb	λc	λc	λa	λd	λe	λf	λd	λj	λk	λe	λf
1	3	4	8	4	1	2	3	1	2	8	7	6	5	7	6	5	8	9	10	7	2	4	7	7
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
5				3			5				2		2		5					3			1	1

SPEED-UP

SPEED-UP

SPEED-UP

SPEED-UP

ONE MONTH

SPEED-UP

ONE MONTH

3902

FIG. 28

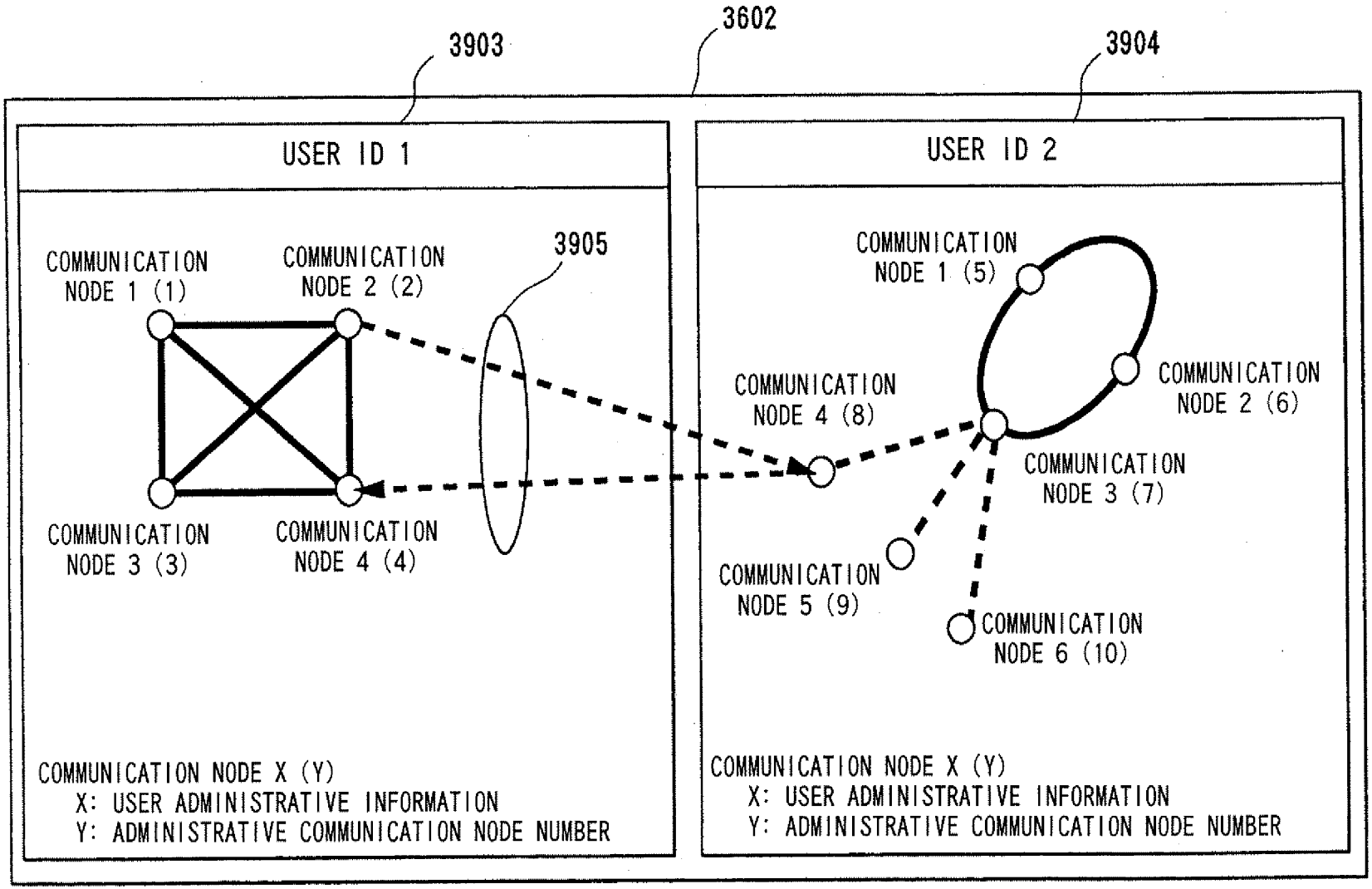
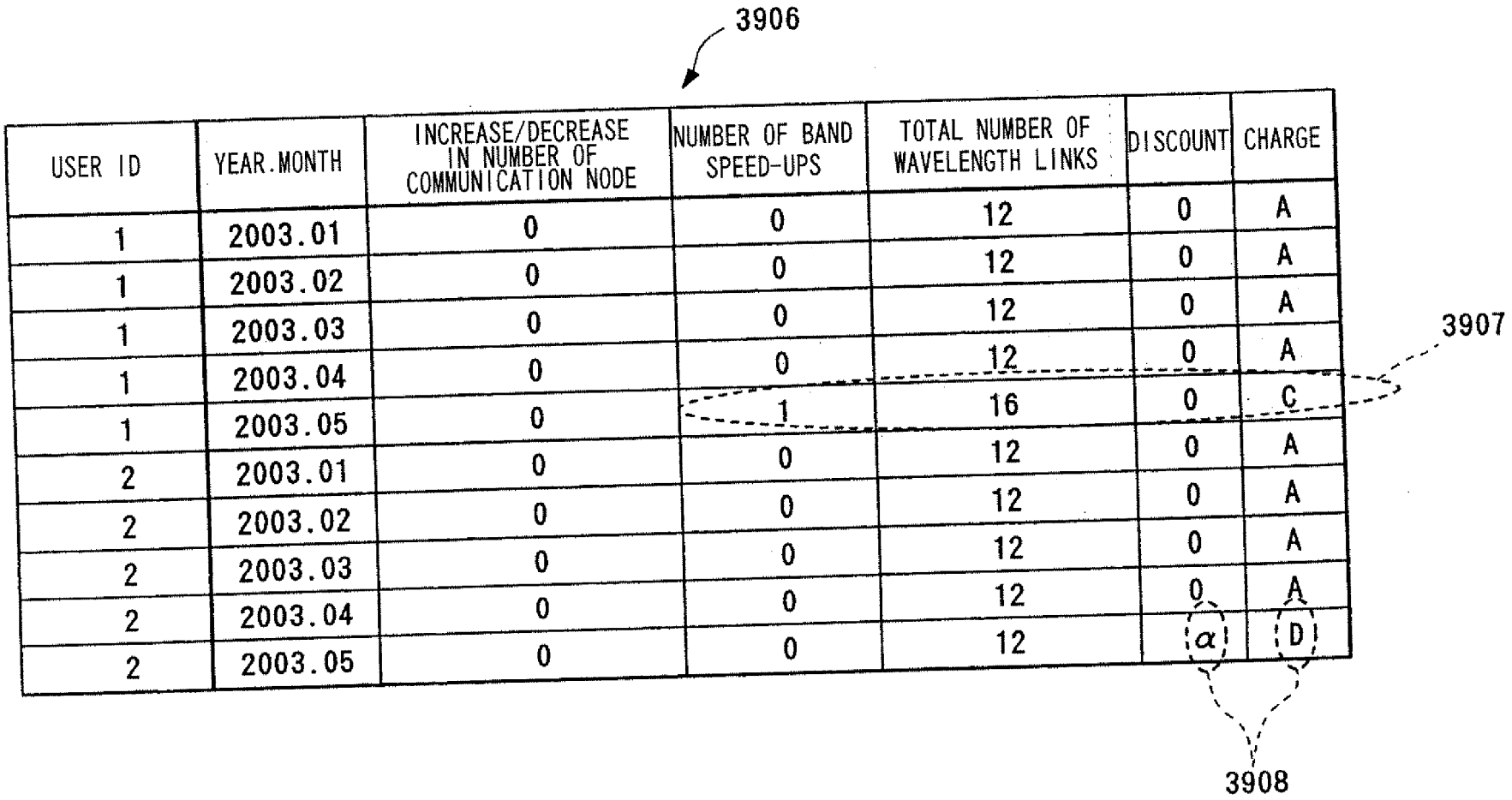
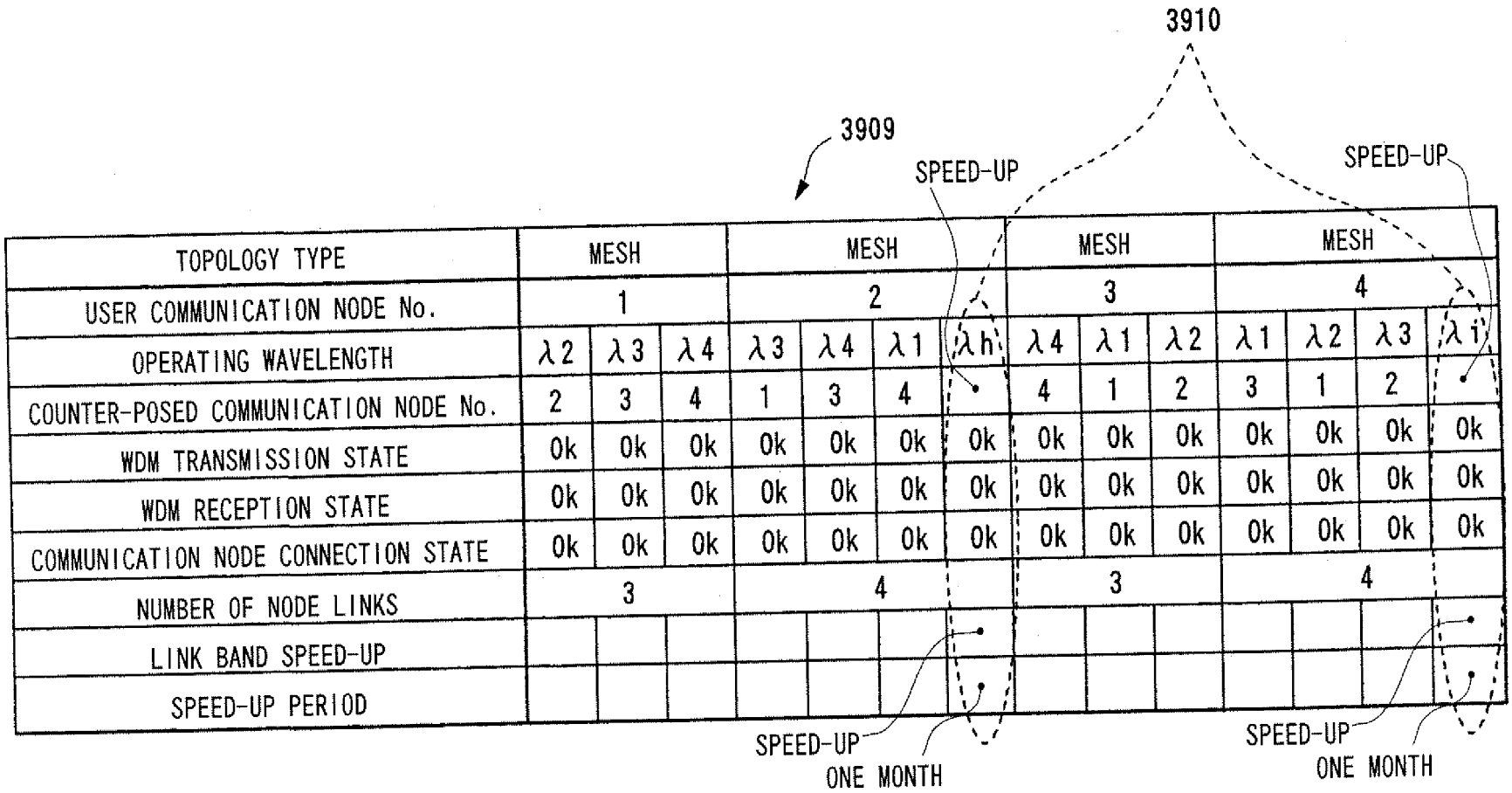

3602
3903
3904
USER ID 1
USER ID 2
3905
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)
COMMUNICATION NODE 1 (5)
COMMUNICATION NODE 2 (6)
COMMUNICATION NODE 3 (7)
COMMUNICATION NODE 4 (8)
COMMUNICATION NODE 5 (9)
COMMUNICATION NODE 6 (10)
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER
COMMUNICATION NODE X (Y)
X: USER ADMINISTRATIVE INFORMATION
Y: ADMINISTRATIVE COMMUNICATION NODE NUMBER

FIG. 29



USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
1	2003.01	0	0	12	0	A
1	2003.02	0	0	12	0	A
1	2003.03	0	0	12	0	A
1	2003.04	0	0	12	0	A
1	2003.05	0	1	16	0	C
2	2003.01	0	0	12	0	A
2	2003.02	0	0	12	0	A
2	2003.03	0	0	12	0	A
2	2003.04	0	0	12	0	A
2	2003.05	0	0	12	α	D

FIG. 30



TOPOLOGY TYPE	MESH			MESH				MESH			MESH			
USER COMMUNICATION NODE No.	1			2				3			4			
OPERATING WAVELENGTH	λ2	λ3	λ4	λ3	λ4	λ1	λh	λ4	λ1	λ2	λ1	λ2	λ3	λi
COUNTER-POSED COMMUNICATION NODE No.	2	3	4	1	3	4		4	1	2	3	1	2	
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	3			4				3			4			
LINK BAND SPEED-UP														
SPEED-UP PERIOD														

FIG. 31

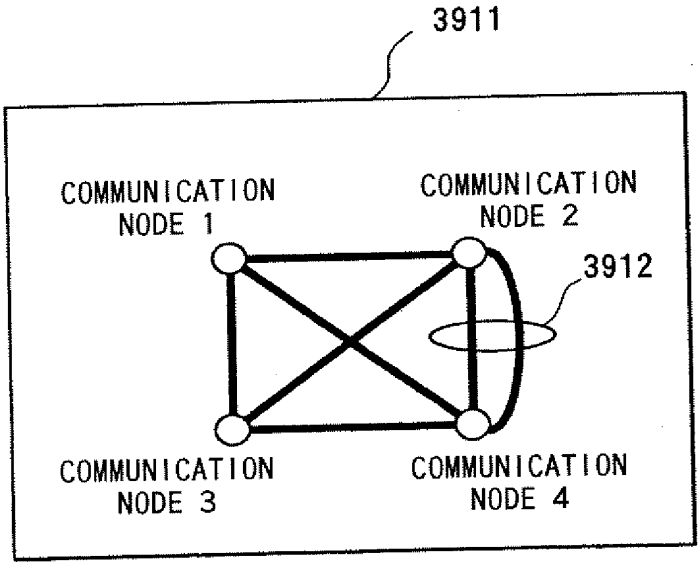

3911
COMMUNICATION NODE 1
COMMUNICATION NODE 2
3912
COMMUNICATION NODE 3
COMMUNICATION NODE 4

FIG. 32

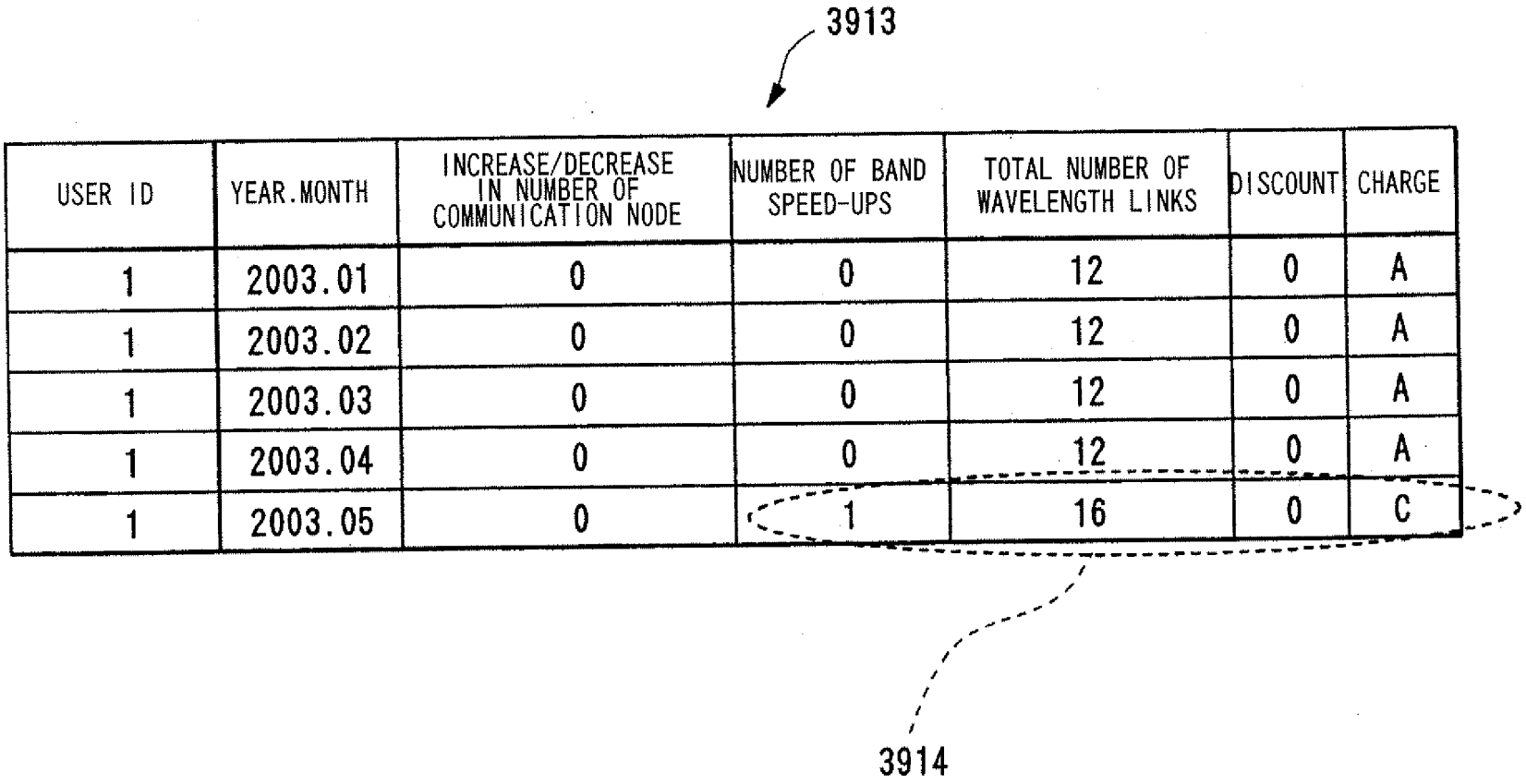

3913
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
1 2003.01 0 0 12 0 A
1 2003.02 0 0 12 0 A
1 2003.03 0 0 12 0 A
1 2003.04 0 0 12 0 A
1 2003.05 0 1 16 0 C
3914

FIG. 33

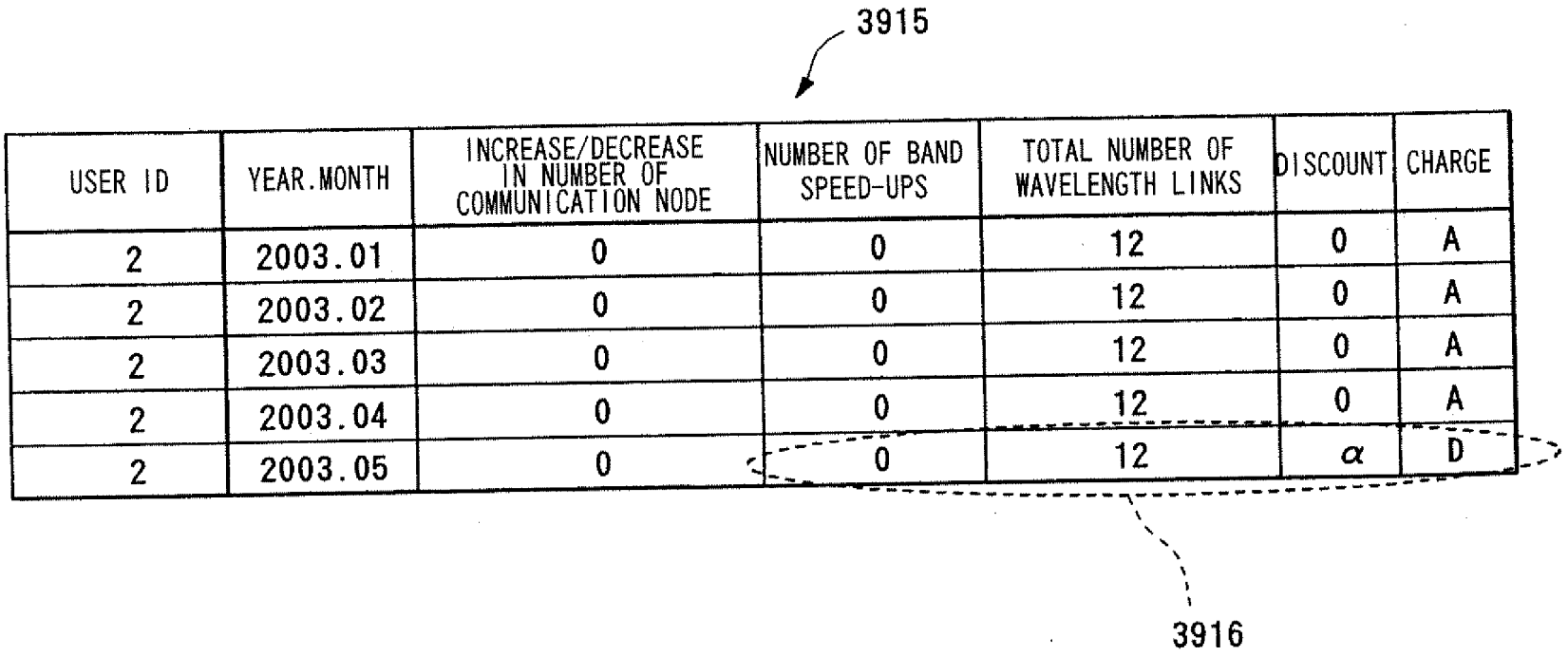

3915
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
2 2003.01 0 0 12 0 A
2 2003.02 0 0 12 0 A
2 2003.03 0 0 12 0 A
2 2003.04 0 0 12 0 A
2 2003.05 0 0 12 α D
3916

FIG. 34

4001

TOPOLOGY TYPE	RING		RING		RING		RING	
ADMINISTRATIVE COMMUNICATION NODE No.	1		2		3		4	
USER COMMUNICATION NODE No.	1		2		3		4	
USER ID	1		1		1		1	
OPERATING WAVELENGTH	$\lambda\delta$	$\lambda\alpha$	$\lambda\alpha$	$\lambda\beta$	$\lambda\beta$	$\lambda\gamma$	$\lambda\gamma$	$\lambda\delta$
COUNTER-POSED COMMUNICATION NODE No.	1	2	1	3	2	4	3	1
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	2		2		2		2	
LINK BAND SPEED-UP								
SPEED-UP PERIOD								

FIG. 35

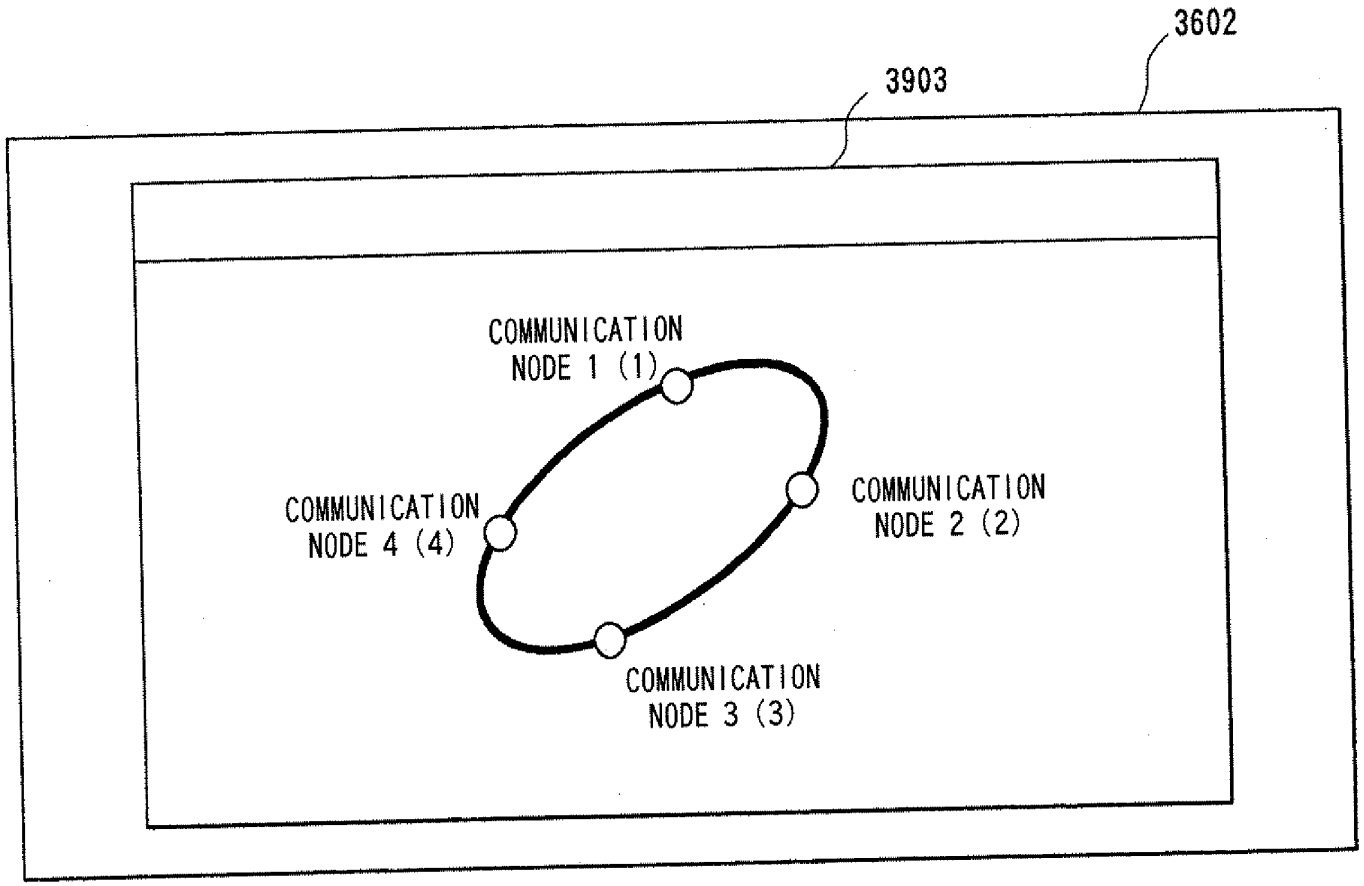

3602
3903
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)

FIG. 36

4003

TOPOLOGY TYPE	RING		RING		RING		RING	
USER COMMUNICATION NODE No.	1		2		3		4	
OPERATING WAVELENGTH	λδ	λα	λα	λβ	λβ	λγ	λγ	λδ
COUNTER-POSED COMMUNICATION NODE No.	1	2	1	3	2	4	3	1
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	2		2		2		2	
LINK BAND SPEED-UP								
SPEED-UP PERIOD								

FIG. 37

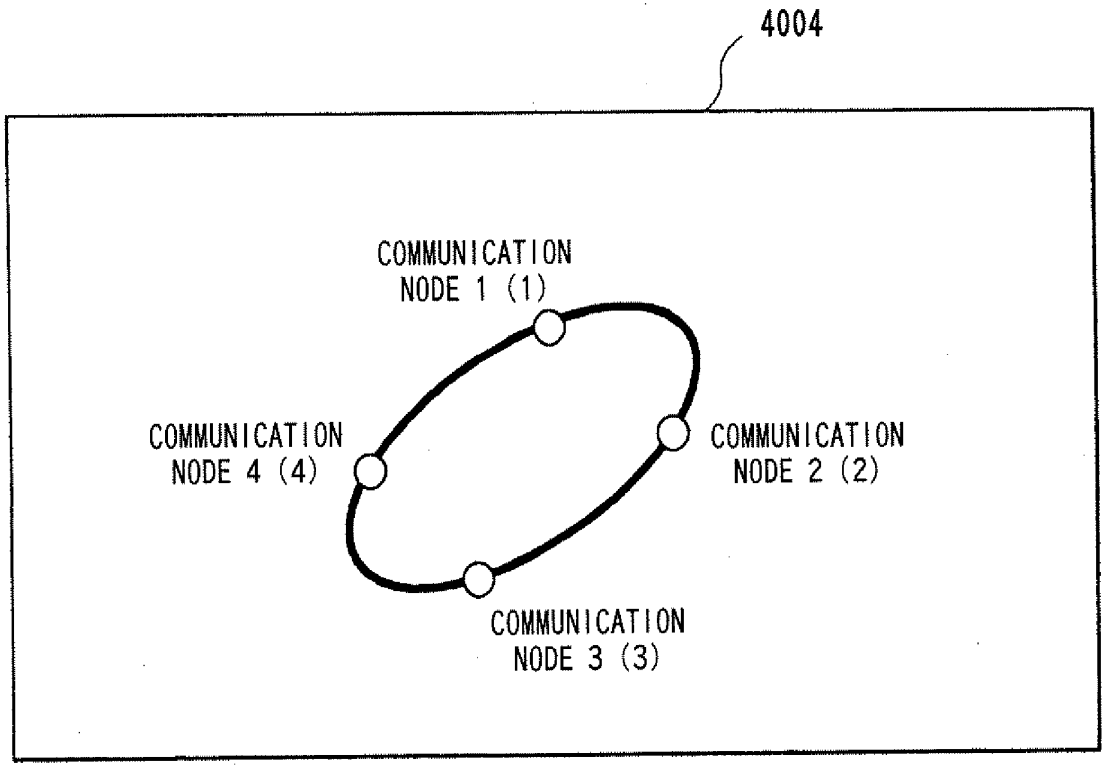
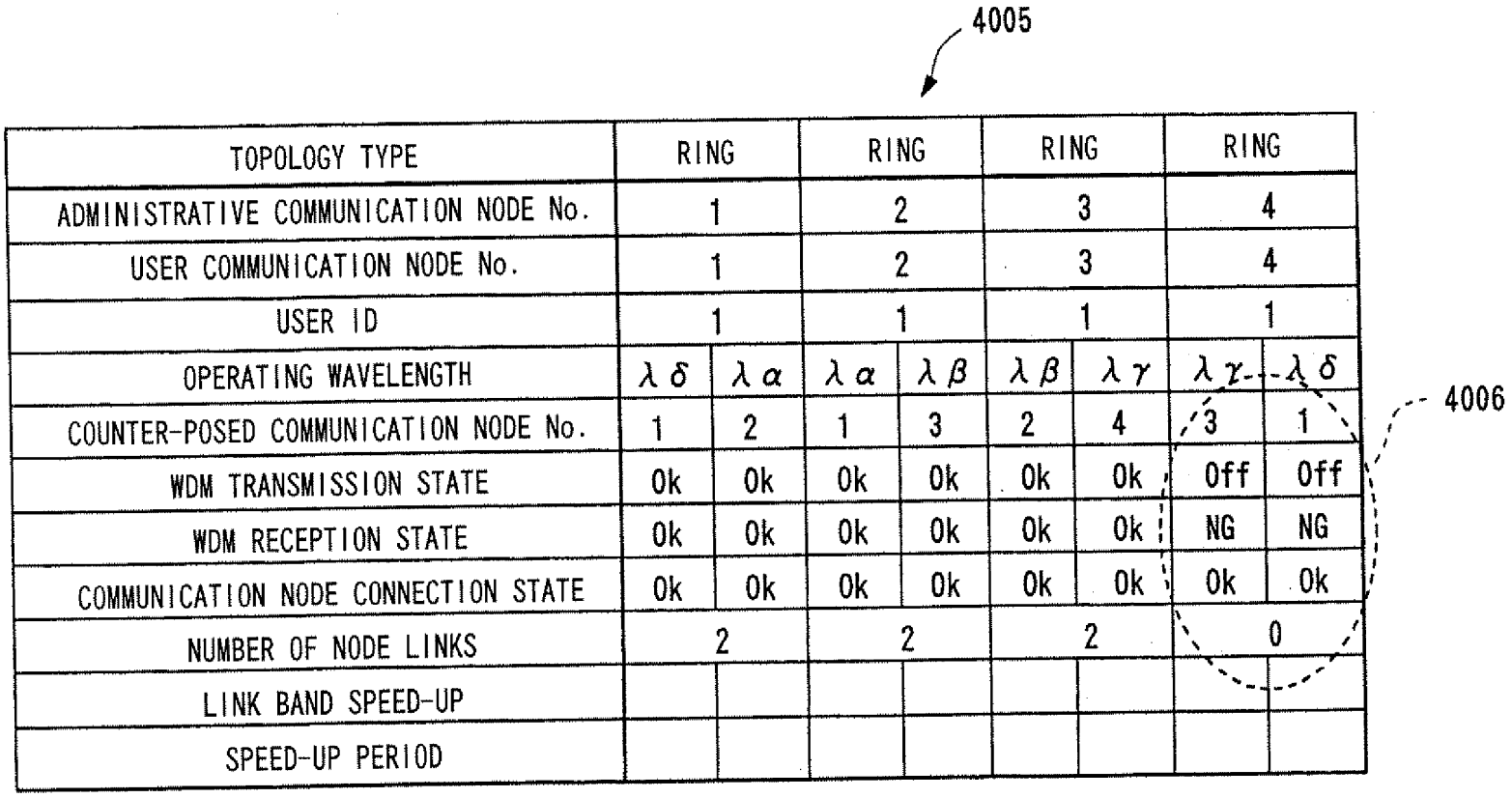

4004
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)

FIG. 38



TOPOLOGY TYPE	RING		RING		RING		RING	
ADMINISTRATIVE COMMUNICATION NODE No.	1		2		3		4	
USER COMMUNICATION NODE No.	1		2		3		4	
USER ID	1		1		1		1	
OPERATING WAVELENGTH	λδ	λα	λα	λβ	λβ	λγ	λγ	λδ
COUNTER-POSED COMMUNICATION NODE No.	1	2	1	3	2	4	3	1
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Off	Off
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	NG	NG
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	2		2		2		0	
LINK BAND SPEED-UP								
SPEED-UP PERIOD								

FIG. 39

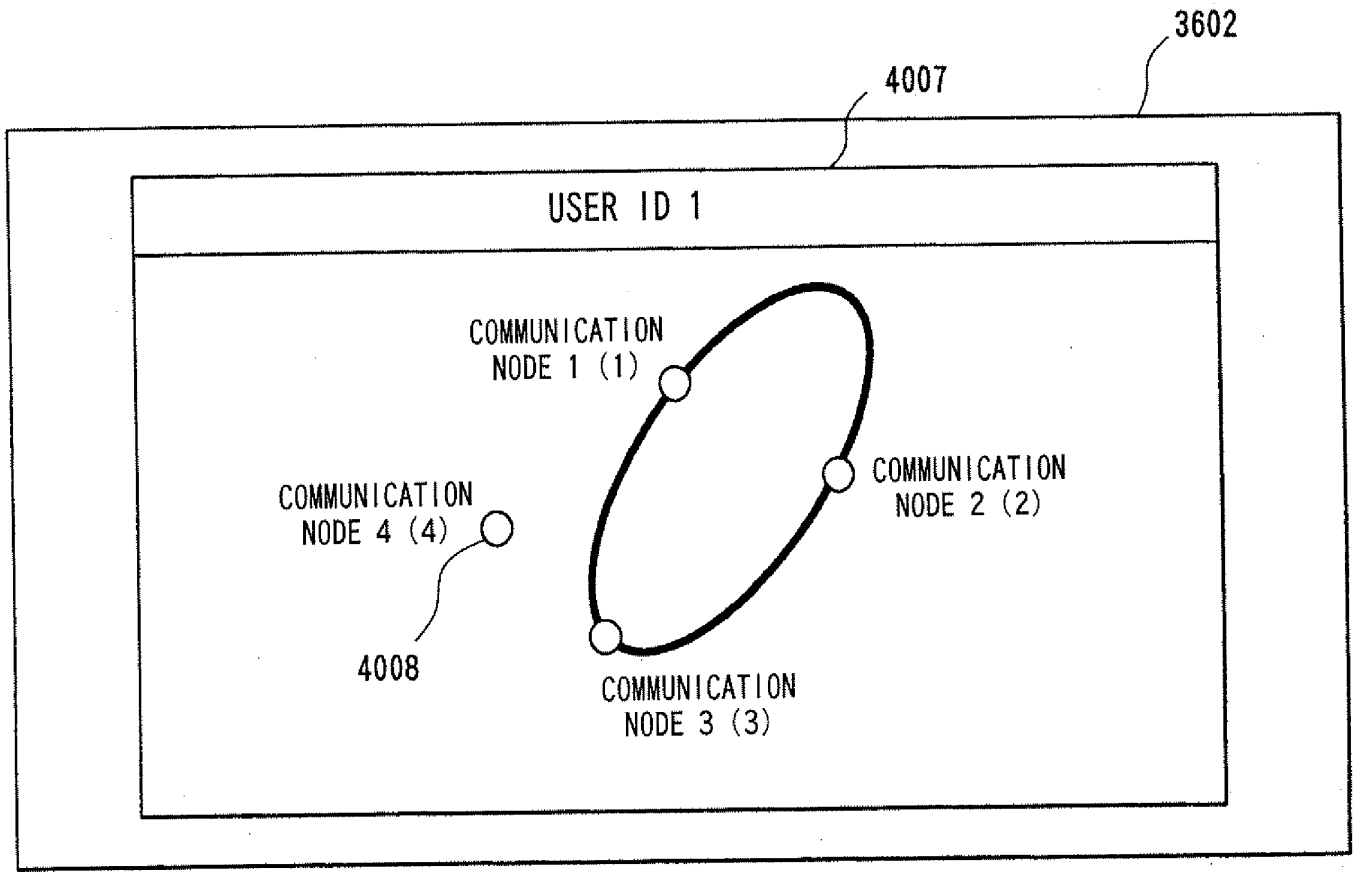
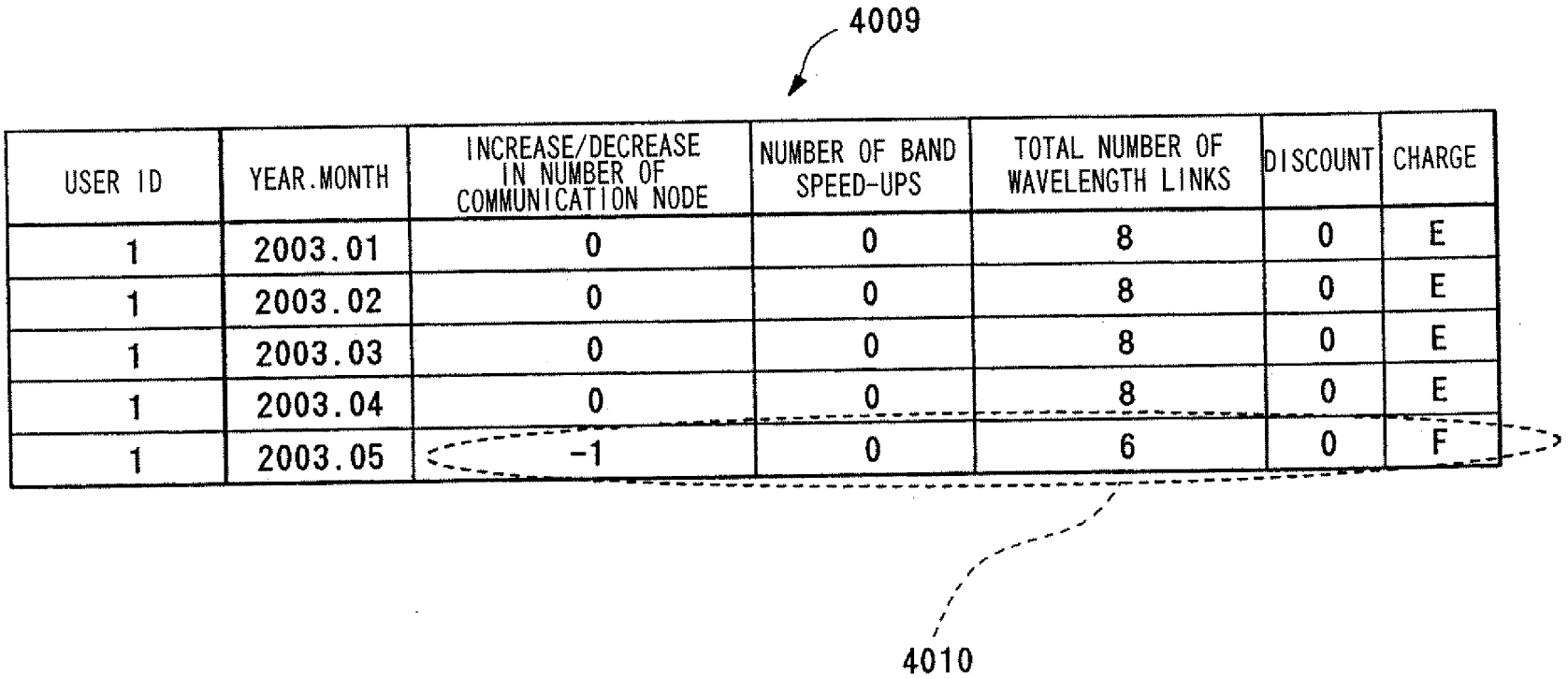
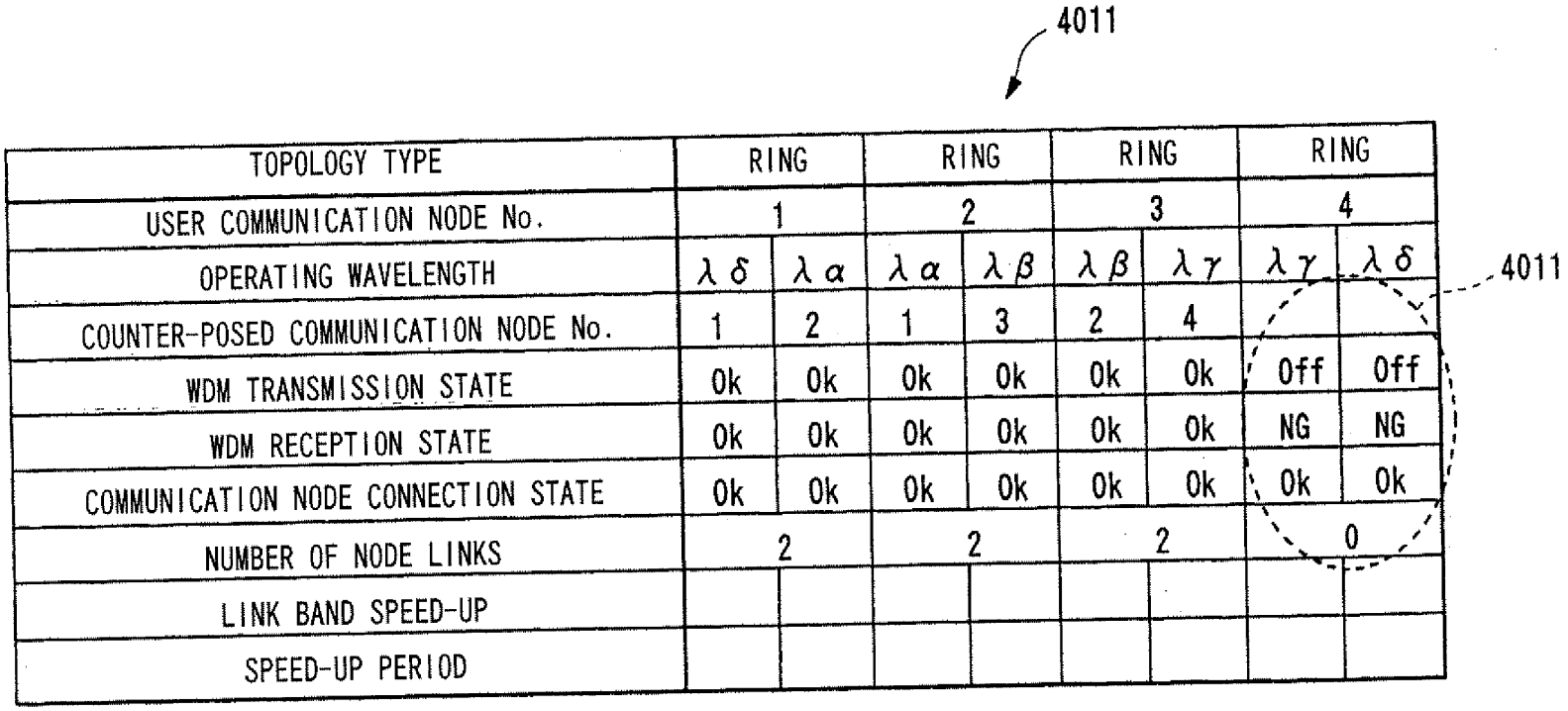

3602
4007
USER ID 1
COMMUNICATION NODE 1 (1)
COMMUNICATION NODE 2 (2)
COMMUNICATION NODE 3 (3)
COMMUNICATION NODE 4 (4)
4008

FIG. 40



USER ID	YEAR.MONTH	INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE	NUMBER OF BAND SPEED-UPS	TOTAL NUMBER OF WAVELENGTH LINKS	DISCOUNT	CHARGE
1	2003.01	0	0	8	0	E
1	2003.02	0	0	8	0	E
1	2003.03	0	0	8	0	E
1	2003.04	0	0	8	0	E
1	2003.05	-1	0	6	0	F

FIG. 41



TOPOLOGY TYPE	RING		RING		RING		RING	
USER COMMUNICATION NODE No.	1		2		3		4	
OPERATING WAVELENGTH	λδ	λα	λα	λβ	λβ	λγ	λγ	λδ
COUNTER-POSED COMMUNICATION NODE No.	1	2	1	3	2	4		
WDM TRANSMISSION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Off	Off
WDM RECEPTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	NG	NG
COMMUNICATION NODE CONNECTION STATE	Ok	Ok	Ok	Ok	Ok	Ok	Ok	Ok
NUMBER OF NODE LINKS	2		2		2		0	
LINK BAND SPEED-UP								
SPEED-UP PERIOD								

FIG. 42

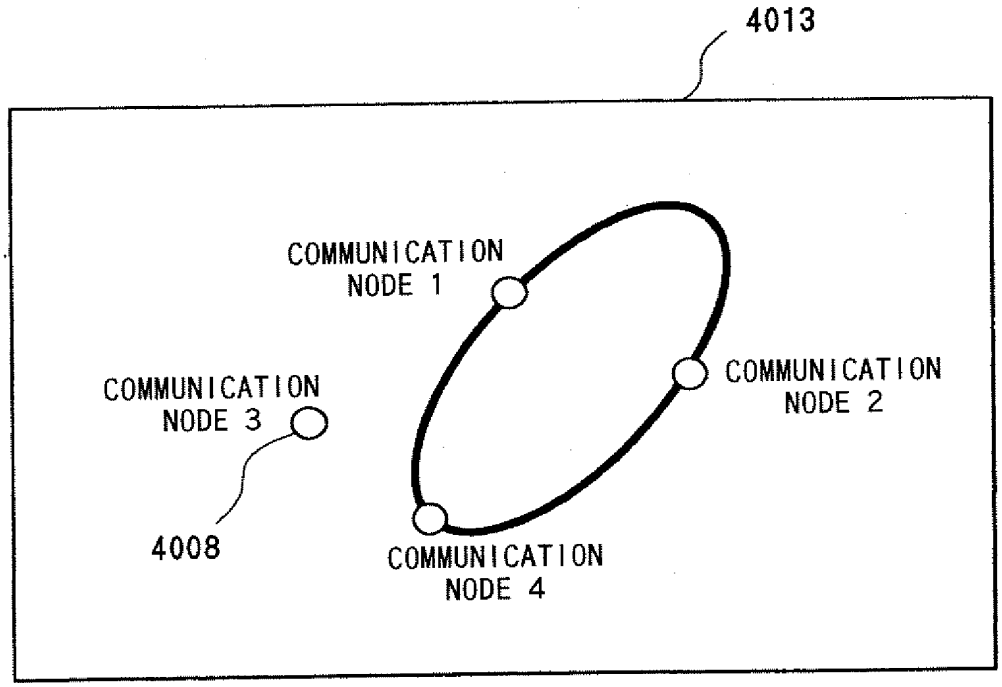
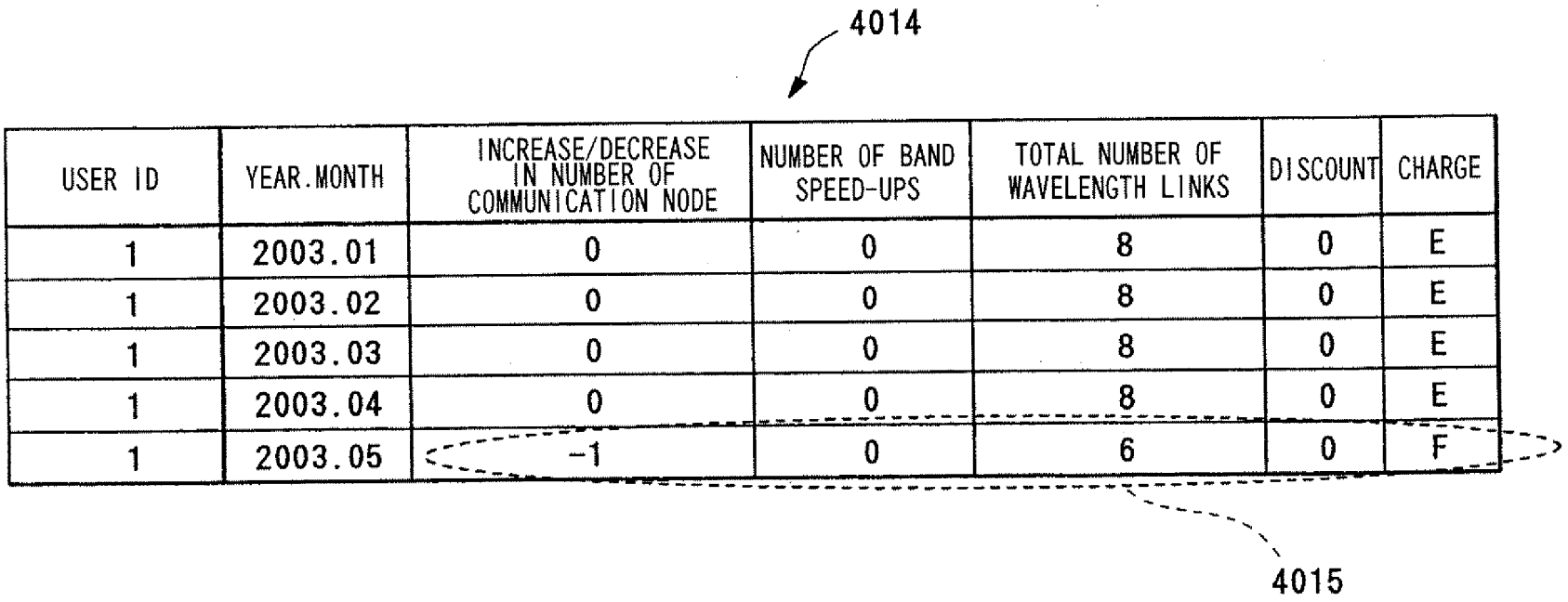

4013
COMMUNICATION NODE 1
COMMUNICATION NODE 2
COMMUNICATION NODE 3
4008
COMMUNICATION NODE 4

FIG. 43


4014
USER ID
YEAR.MONTH
INCREASE/DECREASE IN NUMBER OF COMMUNICATION NODE
NUMBER OF BAND SPEED-UPS
TOTAL NUMBER OF WAVELENGTH LINKS
DISCOUNT
CHARGE
1 2003.01 0 0 8 0 E
1 2003.02 0 0 8 0 E
1 2003.03 0 0 8 0 E
1 2003.04 0 0 8 0 E
1 2003.05 -1 0 6 0 F
4015

[Document Type] Abstract

[Abstract]

[Problem to be Solved by the Invention] To provide a variable topology network system in which the charge to users for the usage of wavelength paths can easily be changed as a result of logical topology changes, addition or removal of communication nodes, and change or addition of wavelength paths for failure bypassing.

[Means for Solving the Problem] A central control unit (2001) that totally controls wavelength tunable light source units (301-304) mounted in communication nodes has a database (2301, 2401). The central control unit (2001) stores the states of wavelength tunable light source units (301-304), connection states between communication node devices (1001-1004) and the wavelength tunable light source units (301-304), connection states between an arrayed waveguide diffraction grating (AWG) (101) and the wavelength tunable light source units (301-304), and data necessary for wavelength distribution calculation for stable operation of the network, performs band speed-up on a link using a specific wavelength between the wavelength tunable light source units (301-304), and administrates the charge for the usage of wavelength sources.

[Selected Drawing] Fig.1